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FOR THE

PROMOTION OF THE MECHANIC ARTS.

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EDITORIAL.

NOTICE.—The publication of the JOURNAL is made under the direction of the Editor and the Committee of Publication, who endeavor to exercise such supervision of its articles, as will prevent the inculcation of errors or the advocacy of special interests, and will produce an instructive and entertaining periodical; but it must be recognized that the Franklin Institute is not responsible, as a body, for the statements and opinions advanced in its pages.

Motive Power of the International Exhibition.—In another place in this number of the JOURNAL, will be found some strictures on the views expressed in the editorial of December, as to the course of the Commissioners in attempting to substitute for the prizes for prominent or acknowledged excellence, usually distributed at the great Exhibitions, a system of awards, founded upon some universal standard of mediocrity ("based on inherent and comparative merit,") judiciously qualified by numerous adjectives. The remarks of our correspondent carry with themselves their own inferences, and, it seems to the editor, sustain fully the conclusions of the editorial, which has only to be read over again to support itself. The point made as to the alleged "award of prizes to all," will scarcely hold when its qualification is recognized, that the "expectation, that the examination of the judges would bring out the most striking novelties, was frustrated by awarding prizes to all" [novel-

ties]. The anticipation that the power of permutation of adjectives might be exhausted in the 700 favorable reports on art subjects, is quite pleasant to entertain, or at least is entertaining to suppose, and the assurance that some weeks yet must pass before the 13,000 pages, paragraphs, sentences, of laudation will be published, is a relief in some regards. The pursuit of knowledge under difficulties would be exemplified in the perusal of this threatened series of volumes—the trial of "patience" is evidently yet to come.

Returning to the exhibition, this want of guidance from the hands of authorized and competent judges is seriously felt in any effort to appreciate its teachings; even an expression of opinion in favor of one or the other exhibit becomes almost imprudent, and the publication of any one of the 13,000 laudations is an admission of its claims to be the "highest prize." Yet it may be worth while to take a short retrospect, and note what steps of progress, if any, have been made apparent in 1876.

The great source of power to-day is the steam boiler and engine. In the steam boiler exhibits it cannot be claimed that much, that was new since the Vienna exhibition, was shown. The chief noteworthy examples were clearly those of Corliss and of Galloway. The Corliss example was that of an arrangement of a number of *externally*-fired-upright-tubular boilers, which, although they are not new ones, are of comparative rarity, and at least novel to most steam engineers; some of the attachments, at all events, were different from common, and the boiler itself presents much facility of construction and of grouping of a number together. The removal of tubes from the zone in the middle of the circle, making a clear water space on an *equatorial* line, so as to admit a free circulation downwards of the return water, after giving up its steam, and also providing access to the tubes on the inside of the boiler for scaling or cleaning, make this boiler a safe one, and one likely to give dry steam. In short, this specimen is likely to add one to the number of approved and accepted forms of the steam boiler of the future, in which the details will be made to pass through the whole train of well known modifications, and possibly be patented as new combinations.

The Galloway boilers were remarkable to American practice as specimens of the Lancashire boiler, which has such an extensive use for the free burning coals of England, as to form a type of national construction. It is expected to give the readers of the JOURNAL a fuller description of the Lancashire boiler at some early day, for

its details present many valuable points for comparison with American practice. The patentable feature of the Galloway exhibit is well known to all engineering readers and this example really attracted much attention. The efficiency for steam-making of the Galloway surface, the ease with which it is cleaned, internally to the flue, or externally to the water space, the satisfactory circulation of water within the boiler, and consequent uniformity of water-level and dryness of steam, were as evident facts from an inspection of the boiler, as they became after a *test*. Either the Corliss or the Galloway boiler will carry sufficient water to meet the demands of varying power or heating capacity without great impairment or wasteful increase of pressure.

The locomotive boilers, in the best forms, were well represented in the various locomotive engines on exhibition, but it cannot be recalled by the writer, that any striking novelty was presented. The boilers of the various steam fire engines were of the usual anomalous construction, and were adapted solely to their specific uses. These specimens of boiler practice with the least of water—generally without a water line—form a singular type of their own, but they will more properly be classed, rather as part of the steam fire engine than as an independent adjunct. Possibly the most extraordinary *boiler* (?) was that of the steam baking apparatus of Perkins, of London, where each tube was sealed by welding up both ends, enclosing a small quantity of water (18 inches in length out of 12 or 14 feet of tube), the air being expelled by boiling the water before welding up the last end; a short end of each of these tubes is exposed to the fire, the collection of tubes forming a fire-box; while the rest of the tube, 10 or 12 feet long, is projected into the oven, the collection of tubes forming the bottom, sides and top of the same. The circulation of steam in these tubes (boilers) is perfect, a slight elevation of the outer end sufficing to allow the condensed water to return towards the fire, while a temperature of 350° to 400° is attained in the oven successfully. There were no examples of any marine boilers, and the Scotch high-pressure marine did not have any exemplar on the ground, nor is it remembered that any models or drawings of this yet novel, but exceedingly valuable, boiler were presented. It should be borne in mind that this Scotch boiler gives an evaporative effect, with dry steam, scarcely equaled by any other, and greatly surpassing the ordinary water tube boilers of patent rivalry and tests, as in fact do most of the accepted types of boilers of usual construction.

As to the other boilers of the Exhibition—are not their records written in the patent office, and will not their merits be set forth in the reports which some weeks hence will demonstrate? It would have been satisfactory to have had one good setting of the ordinary American externally-fired-horizontal-tubular boiler, which now represents about three-fourths the number of stationary boilers in use in this country—a boiler whose duration, economy in prime cost, efficiency as a producer of steam from any fuel; and, above all, whose safety from disastrous accident is second to no other type of known existence. With thirty years' experience, the writer has never known of an accident, which could be called a disaster, with the plain horizontal-underfired-tubular boiler.

The prominent steam engine of the Exhibition was, of course, that of Corliss, whose name is associated with the use of the trip by means of a governor for closing a steam slide valve. It cannot be claimed that this exhibition had the surprise of novelty, for thirty years of persistence has brought this type of engine into recognition as the Corliss engine over all the world, and this particular example is simply a large specimen, with some very ingenious, but not very important, novelties of detail. The most valuable lesson to American millwrights was in the use of cut gearing on so large a scale. The general use of belting in this country, has misled many to the supposition that such use is preferable in all cases to that of gearing, while the truth is that for continuous transmission of a given force, the gear wheel and line of shaft are more economical in wear and in consumption of power. Blowing engines, pumping engines, winding engines, sugar mill engines, and numerous engines for power alone, competed for notice and acknowledgment, but the writer is compelled to say that his most diligent search failed to discover in any of them what would be a marked step in the progress of the steam engine since the Vienna Exhibition. It would be well to publish the details of the American Bull pumping engines, of which there was one example of a type now well fixed and established. The modification of the Cornish valve gear is very peculiar and very effective.

The real step in advance was probably attained in the Davey differential valve movement which was exhibited in the English department. This novelty has been noticed in the JOURNAL, Vol. CII, p. 121, and is unquestionably the most marked improvement in the Cornish or Hornblower engine for a hundred years. The complication of parts, although each was simple in itself, which characterized all

the valve movements of the non-rotative engine from the time of the elder Hornblower, 1720, to the present multiplicity of makers of steam pumps, has disappeared before this means of regulation. Its greatest recommendation is its *safety* provision in preventing injury to the working parts, in case of breakage of pipes, or other accident affecting the constancy of labor of the engine. A reference to another adaptation of this valve movement will be found on the pages of this number of the JOURNAL.

The Otto & Langen explosion engine presents much of novelty. It is unquestionably a recent application of heat-force, but having passed through two previous great exhibitions, it is consequently not entitled to the highest prize. For American practice, however, it is entirely new. Unfortunately it has very restricted limits of dimension, probably it cannot be used with prudence in transmitting, to exceed two horse-power force from any one engine, and for larger demands it quickly becomes altogether impracticable. It is *the* most perfect heat motor ever made, even excepting the gunpowder pile driver, which has the same element of mechanical application. A full description of this engine was given in the JOURNAL, Vol. C, p. 262. The three-cylinder Brotherhood engine, which has met with so large development in England, was represented by a working example in the Brewers' department, but not, it is thought, in any conspicuous manner elsewhere.[1] This engine which has never been offered at any previous great exhibition, promises to form a type of a future class of working steam engines of extensive applicability to special uses.

Marine engines found an admirable example of the right angle crank-Elder-Cowper engine of the most recent form in the exhibit of Messrs. Cramp, of Philadelphia. [The construction of this class of engine without the cumbersome slide valve and ponderous valve movements, by adoption of the balanced poppet or lantern valves, would seem to be possible after our American experience in such valves, for single cylinder engines.] The U. S. exhibit also contained a navy horizontal compound engine of much merit.

In American engines a foremost place should have been given to those of the paddle-wheel steamers of our internal navigation. The

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[1] Since writing the above the writer's attention has been called to the fact that the "three-cylinder engine" formed a part of the exhibit of Messrs. Wm. Sellers & Co., as appears in a very obscure way in that not exceedingly satisfactory publication, the "U. S. Centennial Commission Official Catalogue."

largest steam engines running in the world are those on the Sound steamers from New York. For elaboration of finish, permanency in service, economy in the use of steam, these engines rank among the best. They are the exponents of a class, whose details of construction, and relations of movement of parts, have been established by over fifty years of experience of our most able and competent mechanics and engineers. Any one of them may be taken as a display of perfected mechanism. Their polished side pipes and steam chests, surfaces of silver and golden brightness, often more than a hundred square feet in extent, represent at once both the care taken of the engine, its economy in preserving the heat, and the appreciation of its permanent value when first built. These engines were represented by a small, and generally unnoticed, working model in the exhibit of the Morgan iron works of N.Y. (now John Roach, Chester, Pa.), of the engine of the Bristol steamer, Erastus W. Smith, engineer. Mr. Smith has been the designer or director in construction of most of the larger engines of this character for nearly thirty years. The variable cutting off of steam by tripping the valve each stroke, was attached to engines of this type over thirty years ago, by Sickels; and, with improved details, the Sickels cut-off yet holds its place in their construction. Sickels was the first to propose tripping the steam valve by means of the governor, and patented the application to the poppet valve some years before Corliss perfected a similar application to a slide valve. There was an exhibit of Sickels' models, showing his connection with the growth of the steam engine, which, in the interest of history, ought to be described by some competent writer in the records of this exhibition.

There was a signal omission in the failure to exhibit any specimen, model or drawing of the engines of our western river steamers. Possessing an importance in internal navigation, in the industry of our country, second only to that of the locomotive engine, these steamboat engines of great practical merit, wonderful simplicity, never ending durability, only equaled in this regard by the old pumping engines of Great Britain, were overlooked in *our* national Exhibition. There is no engine so instructive to the schemer on refinements, as the western river engine, and it has great capabilities for economy which are sometimes availed of in the most surprising way.

The locomotive engines were numerously represented, but many of our best makers did not send specimens of their construction; still there was a fair exhibit of the American type of engine on approved

models. It cannot be said that any one of them will be accepted as the engine of the future, or as presenting a type of novelty which shall divert the present practice in any one positive direction. Increase of weight to the degree of excess, perhaps, was the most marked change of the past five years in America. No foreign locomotives were offered in competition, and opinions differ greatly as to the merits of American and European locomotive building, until dispassionate comparison is almost impossible.

The traction and farm engines are beyond the expression of any opinion by the writer, who is free to say that unless his attention was called to specific details of such engines, his want of knowledge of their uses would preclude any judicial view. It may be that the *full* reports of the judges in this group will allow "Americans" to make up their minds as to relative merits; but it is doubtful if many of these will, and certain to the mind of the writer, that most exhibitors will be disappointed in the transferring of the right to judge from the competent judges to an unconcerned public.

It is in the field of comparison of numerous exhibits of one class, that the reports of the judges will, if devoted to description and *avoiding* commendation, possess the highest value. The casual observer, no matter how critical, and even the examiner, no matter how careful, would fail altogether to detect differences or merits, or defects, in the absence of full explanation. One engine was as like another as peas in the same peck measure—criticism fails where appreciation cannot be had. The requirement of a certain order and standard size of illustration, together with some description, such as would enable a competent workman to know how to use the engine, similar to the demands of the Patent Office, might have eliminated some of the difficulties of examination by visitors and by judges.

Instruction at the Franklin Institute.—A course of instruction by Hugo Bilgram, M.E., under the auspices of the Institute, will be given in 12 lessons on the slide valve, on the successive Saturday evenings, commencing January 6th, 1877. Tickets for course, $2.50.

The third course on Phonetic Shorthand, by D. S. Holman, Actuary of the Institute, will commence January 8th; tickets for this course of 12 lessons, $3.00. The previous two courses on this subject have been crowded by scholars, and this class is already filled.

Franklin Institute.

HALL OF THE INSTITUTE, Dec. 20th, 1876.

The stated meeting was called to order at 8 o'clock P. M., the President, Dr. R. E. Rogers, in the chair.

There were present 119 members and 7 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that at the last meeting 19 persons were elected members of the Institute, and the following donations were made to the library:

Thirty-second Annual Report of the American Institute of the City of New York, for the year 1871–72. Albany, 1872. From Wm. P. Tatham.

Blank forms used by U. S. Centennial Commission, from 1 to 210. From P. C. De Sangue, Philadelphia.

Catalogue of the Reproductions of Art Metal Works in the South Kensington Museum, London.

Descriptive Essay of Elkinton & Co.'s exhibit at the International Exhibition of Philadelphia, 1876. From the Hon. Com. of Education.

(To be continued in next number.)

The following Report of the chairman of the Centennial Reception Committee, presented to the Board at its last meeting, was also read:

Philadelphia, Dec. 13th, 1876.

Report of the Centennial Reception Committee to the President and Members of the Franklin Institute:

Gentlemen:—Your Committee, appointed to take charge of the reception room in Machinery Hall, was so subdivided that each member of the committee was expected to attend in the room once a month. The visitors registered their names on entering, and our reception book contains the names and addresses of three thousand and seventy-nine visitors, coming from all parts of the world, from Japan to Russia, many of them being the official representatives of great distinction in their own land. The largest number of visitors was one hundred, on September 28th, "Pennsylvania Day."

The room answered an admirable purpose as a rendezvous for parties interested in the mechanic arts, both at home and abroad, and we believe it has been of great use in popularizing the Institute

and making it better known. The models of interesting machines on exhibition, attracted great attention, and we feel under great obligations to the publishers of the various mechanical and scientific journals, both at home and abroad, for the prompt manner in which they furnished their periodicals, our tables being kept supplied during six months, without expense to the Institute.

We are also under obligations to Mr. Isaac Williams, for the use of a water cooler, and to Geo. W. Childs, Esq., for six months' use of the *Ledger*. Respectfully submitted by

J. E. MITCHELL, *Chairman.*

The Secretary presented his report, embracing John Selter's model of an atmospheric engine; Radde's underground telegraph; a calculating machine invented by Geo. B. Grant; a mowing machine embodying a new mechanical movement, by Wm. Farr Goodwin, and a mechanical horse by the same inventor.

The following letter was read:

Frankford P. O., December 11th, 1876.

Dear Sir.—I have just come in possession of a very fine bust of my deceased father, John Struthers, an old friend of yours, and for many years one of the officers of the Franklin Institute.

The bust is of pure white marble, executed by Canova. Desiring that the Institute should become the custodian of the same if it should be approved by the Board of Managers, I have taken permission to address you, requesting that you would be pleased to make known to the gentlemen officers of the Institute my desire, and kindly requesting a reply at your convenience.

Yours, very respectfully,

JOHN S. STRUTHERS.

To Frederick Fraley.

The Secretary stated that the records of the Institute show that Mr. John Struthers was one of its founders, his membership number being 16, and that he was a member of the Board of Managers continuously from 1827 to 1849.

The following resolution, offered by Mr. Fraley through the Secretary, was unanimously adopted:

Resolved, That the offer of Mr. John Struthers to make the Institute the custodian of the marble bust, by Canova, of his father, the late John Struthers, be and the same is hereby cordially accepted, and that the Board of Managers be requested to make such arrangements as may be needed to receive and care for the said bust.

Mr. S. Lloyd Wiegand offered a resolution, which was amended to read as follows:

Resolved, That the Board of Managers be hereby requested to procure the use for the Institute, an efficient testing machine for testing the strength of materials, when such machine is wanted by the Institute; such machine to be selected by a Committee appointed by the Chairman of the Committee on Sciences of the Arts.

On motion the resolution as amended was adopted.

Mr. Hector Orr, vice-president of the Meteorological Section, made a verbal report that at the meeting held on the 4th instant, a resolution was adopted dissolving the Section, in consequence of "failure of sufficient interest in the Section to maintain the organization."

The President announced, that in accordance with the By-Laws of the Institute, nominations for officers to be elected at the annual meeting in January next, are to be made at this meeting; and that nominations for President, Secretary and Treasurer, to serve one year; one Vice-President, eight Managers and one Auditor, to serve three years, are now in order. The following members were then placed in nomination:

For President, Dr. Robt. E. Rogers.
For Vice-President, Henry G. Morris.
For Secretary, J. B. Knight.
For Treasurer, Frederick Fraley.
For Managers, Prof. Edwin J. Houston, Enoch Lewis, C. H. Banes, Wm. Helme, Saml. Sartain, Dr. C. M. Cresson, Chas. Bullock, Richard McCambridge, H. L. Lipman, Alex. Purves, Mark Balderson, W. Barnett LeVan, Jas. H. Collins, Abram W. Haines, John Sartain, C. Chabot, and W. L. Dubois (declined).
For Auditor, Wm. Biddle.
For one Representative of the Institute in the Board of Trustees of the Pennsylvania Museum and School of Industrial Art,
J. E. Mitchell and J. B. Knight.

On motion, it was

Resolved, That the Secretary be directed to send with the notices of the Meeting in January, a printed list of nominations, giving the occupation and address of each person, and what number is to be elected. The nominations for a representative to the "Museum," to be sent on a separate piece of paper.

The President appointed the following members to act as tellers at the annual election to be held on Jan. 17, 1877: Wm. A. Rollin, W. L. Dubois, Wm. Taggart, John Canby, Geo. Gardom, J. C. Trautwine, Jr., Chas. S. Close.

The Secretary announced that the second quarter of the drawing school would open on Monday, Jan. 8th, 1877, under the direction of Prof. L. M. Haupt; and that the class in phonetic shorthand had been very successful, and that its second quarter will begin on the same date, in the lecture room of the Institute.

On motion, the meeting adjourned.

J. B. KNIGHT, *Secretary.*

Diatoms in Wheat Straw.—In the article on infusorial earth and its uses, published in the last number of the JOURNAL (vol. CII, pp. 407–422), there is a quotation from a report made by Prof. P. B. Wilson, of Washington University of Baltimore, Md., accompanied with a plate of "Forms of Diatoms (alleged to have been) found in Col. Kunkel's straw." From the *Journal of Microscopy*, of August, 1876, it appears quite certain that Prof. Wilson was in error in announcing his *find*, and has permitted himself, either willingly or otherwise, to become an agent in advancing the interests of some fertilizer patent. The *Journal of Microscopy* says: "We have submitted an impression of the engraving accompanying Prof. Wilson's article, to one of our ablest diatomists, and requested him to note for us the names of the 'some thirty-six forms of the diatomaceæ, which he (Prof. Wilson) has carefully sketched.'" The reply enumerates at length a number of marine and fresh water diatoms, sponge spicules, a little of the siliceous cuticle of the straw, and a foraminifer; naming all but five objects, which are left in doubt. "Only one form belongs to the Virginian deposit, with which Kunkel's field was fertilized (?), and which is exclusively marine!"

The *Journal of Microscopy* says further: "Bearing in mind that these organisms, as figured, have been obtained by destroying the organic matter with nitric acid, we find *Bacillaria* figured as it exists only in the living condition—the frustules being joined together in the peculiar way which has given to this form the specific name *paradoxa!!!* For this diatom to have passed through a bath of nitric acid, and come out in the condition figured, would have been almost as great a miracle as the passing of Shadrach, Meshach and Abed-nego unscathed through the fiery furnace of Nebuchadnezzar. So, too, we find a *calcareous* foraminifer figured under the same circumstances! Verily this *is* such a view as has not 'fallen to the lot' of ordinary microscopists to behold—either in twenty, or in

four times twenty years. After such instances, the numerous minor features which are utterly irreconcilable with facts, and which are found in this plate, may be safely passed over."

A close reading of the article of Doctor Wahl will make it evident that he qualifies his belief, and only quotes, with comments, the statements of Professor Wilson; but a more thorough knowledge of the subject of microscopy on the part of the doctor, or on the part of the editor of this JOURNAL, would have avoided the publication of this piece of doubtful science. A previous article by Prof. Wilson appeared in the *American Journal of Science*, for June, 1876. In the September number of the same journal the editors assert that Prof. Wilson was mistaken in the real nature of the objects he examined.

The Davey Movement for Valves of Pumping Engines.—There will be found in a late number of *Engineering* (Nov. 17, 1876), one of the most recent applications of this valve-movement, proposed for a compound engine of the largest class, for use in a silver mine in Nevada. The reader is referred to the description and drawings in *Engineering* for details and arrangement of the engine. The engine is designed to lift 500 imperial gallons (5,000 pounds) of water per minute 4,000 feet high; it being intended to work at five double strokes per minute, and to work ten pumps of 400 feet lift each, nine of the pumps having plungers, and the tenth being a bucket-lift. The dimensions given are: the two cylinders, respectively, 56½ and 113 inches in diameter, and a length sufficient for 10 feet stroke.

	Ft.	In.
Diameter of piston rods,	0	10
Depth of pistons,	1	10
Diameter of steam valve, high pressure,	0	8
" " " intermediate,	1	3
" " " exhaust,	1	6½
" quadrant centre pins,	1	10
Length " " "	3	3
Diameter of main pins,	1	0

The valves are of the Hornblower (lantern) type, and the *time* of lifting, controlled by permitting a lost motion in a link end for each valve rod. Attention is called to the small size of the steam valves, as compared with those demanded for engines other than pumping engines. Their adequacy, however, can be confidently affirmed; but even these dimensions would have been reduced by the use of the

poppet in place of the lantern valve: 6 inch, 11 inch, 13½ inch diameters, respectively, would have sufficed, and the same areas of steam passages have been retained. The side rod and lifter, with wiper shaft arrangement, so common with us, would have been more manageable than the lost motion link.

Lectures on the Weather and its Laws.—Prof. Wm. Blasius, who is very favorably known in the scientific world as the author of a Book on Storms, proposes to deliver a course of four lectures on the above subject. Prof. Blasius has made the subject a study of a life-time and will unquestionably present in form for popular appreciation the general and very abstruse subject of meteorology. It will be gratifying if this effort to exhibit the relations of the observed phenomena of nature, so constantly watched and so much commented upon, as they have been found to exist, shall meet with success. These lectures will be under the auspices of the Philadelphia Board of Trade, and will be given at their Rooms, in the Mercantile Library building, Tenth Street, in January and February, 1877. The days on which they will be given will be hereafter designated. Tickets to the course will be $2.00 each, and those who shall desire to obtain them can do so, by addressing Messrs. Porter & Coates, 822 Chestnut Street, and Prof. Wm. Blasius, P. O. Box 2476, Philadelphia.

Alkalies in the United States.—In another part of this JOURNAL will be found a history of the Alkali manufacture in the district of Glasgow, Scotland, and it may be well to call attention to the consumption in the United States, as indicated by the report of the Chief of Bureau of statistics on commerce and navigation of the United States, in 1873, as follows: In the fiscal year ending June 30th, 1872, there were imported from Europe:

180,028,330	lbs of	Soda,	$3,465,644
28,351,423	"	Caustic Soda,	991,372
1,271,047	"	other salts of Soda,	17,930
15,358,525	"	Bi-carbonate of Soda,	405,253
36,439,597	"	Chloride of Lime,	950,668
261,448,922	lbs. of	Soda product,	$5,830,867

As all these products are bulky, and derived from the cheapest of raw materials, coal, salt, and limestone; the development of American chemical industry in this direction would appear to be one of the most obvious growths to be immediately anticipated.

SYSTEM OF AWARDS AT THE UNITED STATES INTERNATIONAL EXHIBITION OF 1876.

By COLEMAN SELLERS.

An editorial in the December number of the JOURNAL OF THE FRANKLIN INSTITUTE, on the closing of the great exhibition, suggests a few words on what has been termed the American system of awards. The editor says, referring to former remarks of his own on the same subject. "The opinion was expressed that the examination of the judges would bring out the most striking novelties in mechanism, but this expectation has been frustrated by the action which has *awarded prizes to all.* And it is to be regretted, that no means have been otherwise provided for giving publicity or award for special merit." The italics are mine. It is too soon for an advocate of the system in theory, to speak knowingly in regard to the actual advantages of it in practice, but it is not too soon to correct a mistake which the editor, in common with many others, has been led into by the seeming lavishness with which awards have been granted, and in many cases advertised as the "highest." At least twenty-five thousand exhibitors know by this time, or will soon know that their exhibits have not been deemed worthy of any award; doubtless many of them can take just exception to the statement, that awards have been granted to all. The Hon. John Lynch, Chairman of the Committee on Revision, in answer to a recent letter from me, says: "The best information I can find, places the number of exhibitors at 40,000. This is based on the entries on the catalogue; the actual number will overrun this, as a large number of exhibitors are not found in the catalogue.

"The number of Judges' reports, recommending awards, is 13,688;[1] this number includes not only the reports recommending full awards, diploma and medal, but also reports simply recommending diplomas as recognition of merit, but, in the estimation of the judges not entitled to a full award. There are probably 1000 such. The number is also to be reduced several hundreds by duplicates, where judges of the different groups, by mistake reported on the same exhibit. These mistakes arose from the difficulty in determining to what group some exhibits really belonged."

[1] Live-stock awards are included in this number.

From these figures it is safe to infer that the real number of awards made will not reach over 30 per cent. of the whole number of exhibitors. There is yet to be made an analysis of the proportion of awards to exhibitors in each group. The information to enable this to be done is not yet accessible. Who could walk through those vast buildings and note the merits of the selected objects exhibited, and not think one-third of all worthy of some commendation? At London, Paris, and Vienna, medals of various values, either made of more or less precious metal, or engraved with legends which marked their grade of indicative merit, were given to the exhibitors upon the recommendation of international judges. The recipients of these tokens of honor knew only that their wares had been adjudged superior or inferior, by the nature of the award. The value of the higher awards lay in their rarity only. The value of the lower grades has been held by many exhibitors as rather doubtful. The student of the world's progress in the arts and sciences, pays little heed to these metal tokens, but seeks for information in the reports of the experts, sent out by various countries, and in the periodical literature of the time.

It is probable that the United States Centennial Commissioners had in view a possible means of crystallizing the thoughts and opinions of the judges, and making their reasons for each award form part of the premium. Added to this was another seeming advantage: "The awards shall be based upon written reports, attested by the *signatures of their authors.*" Looking over the list of the names of the judges, one cannot but think that some at least must have left the impress of their own mature minds on the judgments bearing their names as the authors. Such I have surely seen, and I cannot but hope these will at least point out for the guidance of future judges, how well such work can be done. The theoretical American award is one "based on inherent and comparative merit," the elements of merit being held "to include consideration relating to originality, invention, discovery, utility, quality, skill, workmanship, fitness for the purposes intended, adaptation to public wants, economy and cost."

About 200 international judges, arranged in groups so as to have each group as far as possible represented by native and foreign judges, have examined the products or wares of over 40,000 ex-

hibitors. They have deemed, we may safely say, 13,000 worthy of award. They have, doubtless, been compelled to use the same language in commenting on many similar worthy objects, but in so doing they simply say that these exhibits are of equal value. To appreciate the difficulties experienced in the first trial of this new system, one must place one's self in the position of a member of that international jury in this new work. The art catalogue alone numbers at least 8,600 exhibitors; may be, awards have been issued to 700. Let any one, by way of experiment, try to arrange words of the English language so as to make each one of the 700 reports differ from the other ones in order of merit. If all the work of the group judges is published, it will be seen that some have made really valuable contributions to our knowledge of the great exhibition. This will be most evident in those cases where reports, apart from the recommendation for award, have been made on every exhibit; that is, where all exhibits have been commented on, and those above a certain standard recommended for award.[1] I think it will be found that the American system of awards will prove to have resulted in a system of awards for intrinsic or actual merit rather than comparative merit. This may be just what the editor of the JOURNAL objects to; but it is probable that it really meets the case better and will satisfy more people than any expression of opinion by any set of men as to relative merit. Americans are very apt to make up their own minds as to relative merit; in some cases large numbers of independent observers may agree, but in most cases they do not. If some judicial body should declare some one sewing machine to be the *best* in the whole exhibition, such endorsement would not influence any of the many thousand users of other sewing machines. On the other hand, if men acting as experts in any particular department, and who are, as far as possible, free from personal bias, give an opinion on actual merit, such opinion usually is listened to and appreciated. So that, after all, there is reason to hope that much positively useful knowledge may yet be gathered for the working of judges on award; and it will be well for those thirsting for knowledge in this direction, "to possess their souls in patience" until the awards have all been published, which is not likely to be done for some weeks yet.

[1] The report of Group II, on ceramics, will, if published entirely, make a large volume, and is full of valuable information.

Civil and Mechanical Engineering.

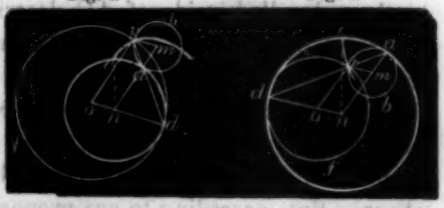
TEETH OF INTERNAL GEARS.

By A. K. Mansfield, M.E.

The chapters on the forms of gear teeth, which are found in the various text books on mechanism, invariably treat of the forms for external gears first, and then declare that the same reasoning and methods apply to the formation of teeth for internal gears. This assertion, however, is only true within certain limits. We therefore take this occasion to show that the theory of the formation of the teeth of internal gears depends on certain facts not entering into the theory of external gears, and therefore that the theory of the former requires a separate and distinct discussion. This theory depends in a great measure on the following proposition, before stating which it will be necessary to define, that by a negative circle is here meant one, the inside of whose circumference is employed; or the inside bounding circle of a ring.

Proposition.—Of three circles, the largest of which is negative, and whose diameter is numerically equal to the sum of the diameter of the other two, if either be employed as base, the other will describe the same epicycloid.

Fig. 1. Fig. 2.



Demonstration.—Let the epicycloid described by rolling one of the smaller circles on the other, be drawn (Fig. 1); also the internal epicycloid, or hypocycloid, made by rolling the same describing circle within the negative circle (Fig. 2).

Through any point p of the curve (either figure) draw the describing circle $a\,p\,b$ resting on the base; and through the same point draw the third circle, also resting on the base, but having its centre on the same side of the line of centres $m\,n$ of the first two circles, as the point p of the curve.

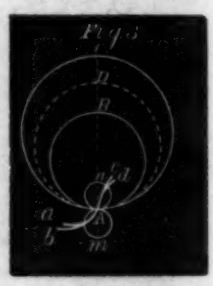
Since the curve was described by the circle $a\,p\,b$, therefore the arc $c\,a$ of the base, is equal to the arc $a\,p$ of the describing circle. Con-

versely, if the arc $c\,d$ of the base, is equal to the arc $p\,d$ of the circle $p\,d\,f$, then the point p is also a point of the epicycloid, beginning at c, of the circle $p\,d\,f$.

Connect the points of contact a and d with the point p, and with the centre n of the base circle; also draw lines from p to the centres m and o of the describing circles.

Since $d\,n$ is a radius of the base circle, it is perpendicular to the point of contact d, and therefore passes through the centre o, of the circle $p\,d\,f$; and in the same way the line $a\,n$ passes through the centre m. Also since $n\,o$ is the difference between the radii of the base and one describing circle, it is, from construction, equal to the radius $m\,p$ of the other describing circle; and similarly $p\,o$ is equal to $m\,n$. $m\,n\,o\,p$ is therefore a parallelogram, and the angle $a\,m\,p = a\,n\,d = d\,o\,p$.

This angle subtends arcs of the three circles proportional to their radii, and since the sum of the radii of the two smaller circles is equal to the radius of the largest, the sum of the arcs of those two circles is equal to the arc of the largest. But the arc $a\,p$ = the arc $a\,c$, therefore $c\,d = p\,d$, and the point p is a point of the epicycloid, starting from c, described by the circle $p\,d\,f$; and this being any point that may be chosen, the same is true of all points of the curve.



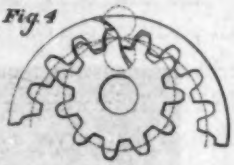
Application.—Let $A\,B$ and $A\,C$ (Fig. 3) be the pitch circles of a pinion and an internal gear respectively, and let $A\,D$ be a describing circle, which rolled on the outside of $A\,B$, describes the curve $A\,a$, for the point of the pinion tooth, and rolled inside of $A\,C$, describes $A\,d$ for the point of the wheel tooth. According to the theory of Camus, which shows that epicycloids described by the same circle, work correctly together, the curves $A\,a$ and $A\,d$, or the *points* of the teeth of the pinion and wheel, will work correctly together, when described as above. But, according to our proposition, the curve $A\,a$ may also be described by rolling the circle $A\,m$, of a diameter equal to the distance $B\,D$, on the outside of $A\,B$; therefore from the theory of Camus, if the same circle $A\,m$ be rolled on the outside of $A\,C$, it will describe a curve $A\,b$ which will work correctly with $A\,a$, and may therefore be used to form the flanks of the teeth of the wheel. In the same way the circle $A\,n$, of a diameter equal to $D\,C$, if rolled inside the circle $A\,B$, will describe the curve $A\,c$, for the flanks of the pinion teeth. Thus the points of the teeth are formed to work cor-

rectly together, as well as the flanks of the teeth of each gear to work correctly with the points of the other.

The circle $A\ D$ may have any diameter greater than $A\ B$, and less than $A\ C$; therefore to form the points to work together, we are only limited to making the sum of the diameters of $A\ n$ and $A\ m$, equal to the distance $B\ C$. If the sum of these diameters were less than $B\ C$ the points would not work together, and the action would be the same as in external gears; but if the sum were greater than $B\ C$ the curves for the points would cross each other, on one side of the line of centres, and the teeth would therefore *interfere*, making their correct action impossible. This leads to the following important rule: *The sum of the diameters of the describing circles for the epicycloidal teeth of internal gears, cannot be greater than the difference between the diameters of the wheel and pinion.*

When the pinion is small, relative to the wheel, it will often be convenient to make the sum of the diameters of $A\ m$ and $A\ n$ less than the maximum; but when the diameter of the pinion is equal to, or greater than, the radius of the wheel, a common describing circle of diameter equal to one-half of the difference between the diameters of the gears, may be the best to employ. The latter case is illustrated by Fig. 4. A principal reason for preferring describing circles of maximum size is, that when the points of the teeth act together, contact takes place through a much longer distance, which enables the teeth to be made shorter and therefore stronger. The path of contact of the points, is the circle $A\ D$ (Fig. 3), and of the points with the roots, the circles $A\ m$ and $A\ n$.

Fig 4



If the diameter of one of the describing circles be equal to $B\ C$, the other becomes zero. In this case, one of the curves $A\ a$, $A\ d$ becomes a point in the circumference of its base circle, and the other curve works correctly with this point, as well as with its own corresponding flank curve $A\ b$ or $A\ c$. Fig. 5 illustrates the case in which the circle $A\ m$ becomes zero, and Fig. 6 that, in which $A\ n$ is zero. In each of these cases we have drawn a circle about the point mentioned, which made it necessary to

Fig 5

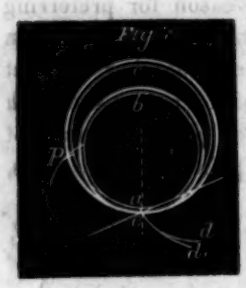
Fig 6

form the other acting faces of the teeth, of curves parallel to the epicycloids, at a distance from them, equal to the radius of the circle or point.

In the case of Fig. 5, if the diameter of the pinion be two-thirds that of the wheel, the flank of the pinion tooth becomes a straight line, parallel to the radius through the centre of the tooth.

By completing the circles which form the points of the teeth, and omitting the flank curves, we have the so-called pin wheels or trunnions, of which we distinguish three cases, viz.: Those in which the diameter of the pinion is (1) less than, (2) equal to, and (3) greater than the radius of the wheel. In case 1, the teeth should be given to the driver, and the pins to the follower, as in external gearing.[1] In case 2, the pinion should always receive the pins, since in that case contact will be equal on each side of the line of centres, whether the pinion be driver or follower. In case 3, it is immaterial whether the pinion or the wheel receives the pins, since in either case contact takes place before the line of centres when the wheel drives, and after when it follows; therefore, if the wheel drives, the objectionable contact, entirely before the line of centres, cannot be avoided.

Involute Teeth.[2]—In applying involute teeth to internal gears it will be found, as before, that under certain circumstances the teeth interfere. For example, in Fig. 7, in which *a b* and *a c* are the base circles, and the curves *c d*, *c d*, the involutes of those circles, when the pitch circles are rolled about until the involutes arrive at the new position represented in the figure, they cross each other, at the point *p*. To avoid the consequent interference of the teeth, either smaller base circles must be employed, or the points of the teeth made short enough, so that the circles limiting those points cross each other either at, or before, the point *p*.



Internal gears work with much less friction than external, and occupy less space; besides which, the outer ring of the wheel forms a good shield to prevent accidents. For these reasons it seems advisable to use them in preference to external gears, when other considerations do not prevent.

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[1] See Willis's "Mechanism," § 132.

[2] See the same, § 165

CERTAIN POINTS IN THE DEVELOPMENT AND PRACTICE OF MODERN AMERICAN LOCOMOTIVE ENGINEERING.

By Francis E. Galloupe, S.B.

Continued from Vol. cii, page 390.

The formula by which to calculate the strength of the cylindrical shell of a steam boiler, though very simple, is quite important, and may be thus deduced:—[1]

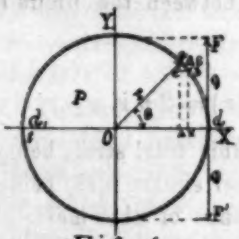

Fig. 1.

Let the figure represent a section or ring of the boiler whose internal radius is r inches; thickness t, in fractions of an inch; and its length, perpendicular to the plane of the paper, one inch or unity. Let this thin hollow cylinder be under an internal pressure, the intensity of which is p pounds per square inch, and let f be the ultimate tenacity of the material. This stress, p, is everywhere normal to the circumference, and the lines which represent its direction, of which there would be an infinite number, all radiate from the centre O.

The resistance of the material to this stress acts everywhere in a direction perpendicular to the direction of the stress p, or tangential to the circumference.

Consider the stress resisted by the cross-sections at d and d^1. The stresses along the horizontal axis X, in both directions from O, do not tend to burst it at these cross-sections. At d and d^1, the horizontal stresses tend to push out the lower half just as much as the upper, and there is no tendency to slide one cross-section by the other. Only the vertical stresses upon one-half the shell, in the direction $O\,Y$, tend to separate the cross-sections at d and d^1, and they are resisted by equal and opposite forces normal to these horizontal sections and represented by q, or $d\,F$ and $d\,F^1$.

Now, for any intermediate direction, let the stress p be represented in magnitude and direction by the line r, which makes any angle θ, with $O\,X$. Only its vertical component, $p \sin \theta$, acts, and the total

[1] There are a number of ways of proving this; one method is given by Rankine, another by Forney, and a different one still by Weisbach.

stress is the sum of all these components, acting upon one-half the circumference, from d to d^1, on the upper segment, or

$$P = \Sigma \cdot p \sin \theta.$$

Each of these stresses acts on a unit's length of cylinder and on a short arc in the circumference of a length $\triangle s$. Let fall from a and b, the extremities of this arc, perpendiculars on $O X$, and draw $b c$ parallel to $O X$. $a b$ is, for so short an arc, practically perpendicular to $O a$; hence the angle at a equals θ. Now $\sin \theta = \frac{b c}{a b} = \frac{\triangle x}{\triangle s}$.

Therefore, $P = \Sigma \cdot p \frac{\triangle x}{\triangle s}$, and integrating x, between the limits d and d^1, the arc drops out, or

$$\int_r^r p \frac{d x}{d s} d s = p \int_r^r x = p r - (-p r) = 2 p r.$$

The thickness of metal at d and d^1, to resist this total stress being t, its area is $t \times 1$, and the strength in lbs. per square inch, being represented by f, as above, the total resistance of the material $= 2 f t$. Therefore, if we put these results equal to each other we have, $2 p r = 2 f t$, or

$$p r = f t, \text{ and } p = \frac{f t}{r}, t = \frac{p r}{f}, r = \frac{f t}{p},$$

which express the relation between these four elements, by which we can obtain the value of either one when the other three are known.

To find the strength of the sections in resisting the pressure upon the ends, as upon the tube plates, we have the total pressure, $P = p \times \text{area} = p \cdot \pi r^2$. The resistance against rupture is that of the whole circular cross-section, or

$$\pi (r + t)^2 - \pi r^2 = 2 \pi r t + \pi t^2 = 2 \pi r t \left(1 + \frac{t}{2 r}\right).$$

Now, as the ratio $\frac{t}{2 r}$, of the thickness to the diameter is a very small fraction, in this case being $\frac{\frac{3}{8}}{48} = \frac{1}{128}$, it may be neglected, and the resisting area assumed to be represented by a rectangle of the length $2 \pi r$, and width t. Multiplying by f, we have the total resistance $2 \pi r f t$, and $2 \pi r^2 p = 2 \pi r f t$, or

$$p r = 2 f t, p = \frac{2 f t}{r}, t = \frac{p r}{2 f}, r = \frac{2 f t}{p},$$

or the pressure upon the ends may be twice as great as in the former case.

In these formulæ the assumption is made that the stress is uniformly distributed over the cross-section, which is only approximately true for thin shells. In the sphere we have the latter case for every diametral section, and hence the sphere is the strongest of all known forms for steam boilers. Internal pressure tends only to preserve its shape; if from any cause a spherical boiler is out of shape, the pressure would tend to reduce its distortion and restore it to the true spherical form. The sphere also contains the greatest volume within a given amount of surface or material. As far then as strength alone is concerned, we see why boilers should have the spherical form.

To ascertain the reduction of strength due to the riveted joints, there are a number of easily deduced formulæ which give approximately the best relations in practice between the thickness of the plate, and the diameter and pitch of the rivet. The strength of the plates along the line of rivet holes, according to deductions made from Sir Wm. Fairbairn's experiments, by Wilson in his "Treatise on Steam Boilers," after taking into consideration the loss of strength due to the treatment the iron has received, the diminished section of plate through the line of rivets, and the excess of strength in long over short lines, is regarded as 70 per cent. for double riveting, and 56 per cent. for single, of the strength of the entire plate.

The rivets in this boiler are $\frac{11}{16}$ inch in diameter; heads, 1 inch in diameter $\times$ $\frac{3}{4}$ inch in height; set, the first row $1\frac{1}{4}$ inches from the edge of the plate; the second, $2\frac{1}{4}$ inches; and the pitch, 2 inches or $1\frac{15}{16}$ inches.

The plates in a steam boiler are under these conditions: First, there is an indirect strain upon the rivets and plate, on account of the overlapping joint, for the internal pressure causes a tension, the line of action of which passes through the centre of the united plates, and thus tends to bend the rivets out of their original position at right angles to the plates. Next, the plates lose strength on account of an irregular distribution of the stress coming upon them, due to the punching of the plate for the rivets. And finally there is the loss of strength due to the amount of material cut away for the rivet holes, and the action of the rivet in producing strains in the plate.

The weakness of the joint may exhibit itself in a number of ways, —by the plate in front of the rivet crushing, by the rivets shearing off, the plate tearing between the rivet holes, splitting from the rivet holes to the edge of the plate, or by the plate being forced out by a wedge-like action of the rivet; all of which have to be considered in determining the greatest strength attainable with our present system of riveted boilers.

If we call, in the present case, the diameter of the rivet $d = \frac{11}{16} = \cdot6875$ inch; the thickness of the plate, $t = \frac{3}{8} = \cdot375$ inch; and the pitch, $p = 2$ inches; and take the resistance of the plate to crushing at 40 tons per square inch, the first of these, the resistance of the plate to crushing by each rivet, would be:

$$d \times t \times 40^1 = \cdot6875 \times \cdot375 \times 80{,}000 = 20{,}624 \text{ pounds.}$$

Second, the ultimate shearing strength of the rivet, calling the resistance to this strain, 21 tons, is found by multiplying the area sheared by the strength per square inch, or

$$\tfrac{1}{4}\pi d^2 \times 21 = \cdot7854 \times \cdot4726 \times 42{,}000 = 15{,}586 \text{ pounds.}$$

The condition for the greatest economy in material is that when these two values are the same, or the strength of the rivet and plate are equal, any excess of strength one above the other being of no value. This condition is represented by putting these two terms equal to each other, or

$$d \times t \times 40 = \cdot7854 \times d^2 \times 21,$$

whence $d = 2{\cdot}4\ t$. Judged by these two requirements alone, the diameter of the rivet should be ·9 inch instead of ·68; but it agrees with the common rule of making the diameter double the thickness of the plate.

Third, the strength of the plate left between the rivet holes, *for a single row of rivets*, may be found by the equation, $R = t\ (p - d)$ 21, or ·375 (2·00 — ·75) 42,000 = 19,688 pounds. In this the diameter of the rivet hole is taken at $\frac{7}{8}$ inch, or $\frac{1}{16}$ inch larger than that of the rivet, as this has been found to be the average size in practice. Now for equality between the strength of the rivets and of the plate left between the holes, we form the equation,

$\frac{1}{4}\ d^2 \times 21 = t\ (p - d)\ 21$; from which the proper pitch to be employed is found to be $p = \frac{a}{t} + d$, a being the area of the rivet.

[1] These formulæ are Wilson's, and his value of the ultimate resistance of the material to the different stresses are taken as being reliable and probably below that of the material in this boiler.

For a double riveted lap joint, Mr. Wilson states that we have the sectional area of two rivets to shear instead of one, and employs the formula $2\,a = t\,(p - d)$; whence,

$$p = \frac{2\,a}{t} + d = \frac{\cdot 7422}{\cdot 375} + \cdot 687 = 2\cdot 66,$$

or about $2\frac{5}{8}$ inches instead of 2 inches, which it has in this case.

From the strength of the plate to resist splitting from the rivet to the edge, we ascertain the proper distance that the first row of rivets should be placed from the edge of the plate. This is done by considering the plate as a girder fixed at both ends and uniformly loaded, by which we find, roughly, that the depth $h = \cdot 81\ d$, which indicates that in this case the depth of $1\frac{1}{4}$ inches comes far within this requirement, upon the safe side.

The consideration of the last effect, or the wedge-like action of the rivet, is unnecessary, as the resistance in this case exceeds that in all the other respects.

In locating the second row for the double riveted seams, a circular arc is described from the centres of two successive rivets in the first row, and with a radius equal to one-half the pitch. The intermediate rivet is located so that its circumference is tangent to each of these arcs. Now the shortest distance between two holes is that between two rivets in a diagonal row, and is equal to $\frac{1}{2}\,p - \frac{1}{2}\,d$, or $\frac{1}{2}\,(p - d)$. The resistance of this portion of plate is, therefore,

$$\tfrac{1}{2}\,(p - d)\,t \times 21 = \tfrac{1}{2}\,(2 - \tfrac{3}{4})\,\tfrac{3}{4} \times 42{,}000 = 9{,}840 \text{ pounds.}$$

The section of plate, and consequently its strength, between three successive rivets, irrespective of the rows they are in, is therefore equal to that between two successive rivets in the same row; and the ratio that the strength of this portion of plate bears to the whole plate is as the length, $(2 - \frac{3}{4})$, is to the pitch, 2 inches; or $62\frac{1}{2}$ per cent.

The boiler as a whole derives additional strength from the length of seam, the breaking of joints, and especially, by the double thickness at the overlapping edges around the circumference. The amount of this is considered to overbalance the loss due to punching, and the unequal distribution of stresses, sufficiently to make it safe to take the strength of the double riveted seams as at 70 per cent. of the strength of the boiler plate. Where the single riveting exists, we have seen that the stress is but one-half that upon the double riveted, while the strength of the seam is 56 per cent.

of that of the entire plate, or much greater than half of 70 per cent., and these seams may hence be left out of consideration.

We may now determine the actual boiler strength. Applying the formula that has been deduced, $f = 52{,}102$, $t = \frac{3}{8}$ inch, $r = 24$ inches. Hence the ultimate, or bursting pressure,

$$p = \frac{f \times t}{r} = \frac{52{,}102 \times \frac{3}{8}}{24} = 814{\cdot}1 \text{ lbs. per square inch.}$$

seventy per cent. of $814{\cdot}1 = 569{\cdot}87$ lbs. Now, to determine with what factor of safety this locomotive is running, we have the usual steam pressure, varying from one hundred and forty, to one hundred and forty-four or five pounds, and it being not improbable that from a slight cause it would reach one hundred and fifty, $\frac{569{\cdot}87}{150} = 3{\cdot}8$, and at 140 lbs. pressure the factor of safety is but 4. If it was not for constant attendance, this might be regarded as rather hazardous, and 6, as given by Rankine and Wilson, would be the better figure. This result indicates the great difference between the factors of safety of different parts, the mechanism in some parts having as great a factor as 30, while the positive, live force of steam has but 3 or 4. From the wearing or corroding of the plates they become thinner, a usual rule in regard to which being to deduct one-fifth for deterioration after several years; and this is allowed for, in the locomotive, by reducing the working pressure, perhaps 20 lbs., and running at 120 lbs., making of it what is known as a second class engine.

It is unnecessary to calculate the strength of other parts, such as the tube sheets, which are thicker and heavily stayed, and the fire-box flat sides; for these are determined by other considerations, such as stiffness, and resistance to bulging. The unvarying rule is that the fire-box stays shall not be more than four inches apart, and they are usually twice the thickness of the plates in diameter.

In the flues the tendency of pressure is the opposite of that on the shell. While, in the shell, internal pressure tends to make it a perfect cylinder, in the tubes, a slight distortion is further increased by the unbalanced external pressure; but from their small diameter the strain resulting from the compressive force, is not, in general, equal to that exerted by pressure on the shell.

The collective pressure inside a locomotive boiler is immense. To obtain some idea of what it would be, the calculation was made for the

shell alone. Its volume, exclusive of the tubes, is very nearly 100 cubic feet. The number of square feet of surface in the shell is 138·23; on each tube plate, after deducting the area of the tubes, 9·05; and on the tubes 927·3. On every square inch of this there is a pressure of 140 lbs., or 20,160 lbs. upon the square foot, so that upon the shell alone it amounts to 2,786,717 lbs.; on the tubes alone, 9,344 tons; and the total upon the boiler, 10,740 *tons*.

But there are other forces much more violent than this which the locomotive boiler has to daily withstand. It has been stated that the boiler is the back bone of the locomotive engine. Upon it are placed many attachments; it is cut up by large holes and most of the sheets punched for stay bolts, braces and outside attachments, whose weight alone tends to distort it. Then there is the force of expansion which is very unequal in different parts. On raising steam in this boiler it lengthens from $\frac{3}{16}$ to $\frac{1}{4}$ inch. Formerly no allowance was made for this in bolting it to the frame, and the immense stress thus produced caused it to rise in the centre, but which was partially counteracted, however, by the weight of the water, which in this boiler with two gauges full is 3,125 lbs., or over a ton and a half. As now constructed, the side-frames are supported at the fire-box end in straps which permit the boiler to slide along the frames during expansion and extend back into the cab. The frames are placed $\frac{1}{2}$ inch from the sides of the fire-box, and notwithstanding the fact that the expansion or bulging out of the plates must be greater inside the fire-box because of the high temperature, the external fire-box is found to expand $\frac{3}{32}$ inch towards the frames.

As a whole, the apparently rigid boiler is not so in reality. It is yielding in every direction, and the elasticity of iron is at once an advantage and a defect in the use of the material for locomotive construction.

The Furnace, in a locomotive, consists of the external fire-box, whose parts include the furnace door, the ash pan and ash pan dampers; and the internal fire-box, whose parts are the grate, the crown sheet, crown bars and furnace stays. It is strengthened on its large flat surfaces by stay bolts, which are sometimes made hollow, both to admit air to the gases above the fire and to give warning by leakage when they become useless from corrosion. These are screwed into each plate and riveted upon the ends. The crown sheet is strengthened by double, or pairs of, crown bars; each

bar of a pair is $\frac{3}{4}$ in. in width by 5 inches in depth, the double bars placed $4\frac{1}{2}$ inches apart. Each pair is joined together by welding at the ends, and is attached to the crown sheet by bolts passing between them. The crown bars are set off from the crown sheet by smooth, circular washers, $\frac{1}{2}$ inch thick, which allow the circulation of water around them, beneath the crown bars, over the surface of the plate.

II. *The Heating Surface* includes all the internal surfaces of the boiler exposed to the hot gases upon one side of the plate and in contact with the water upon the other. Its extent is limited, practically, only by the size of the boiler. The more that can be introduced in it, the greater the available heat, of the total produced by the combustion of the coal. The usual ratio to grate area is 50 square feet for each square foot of grate.

The dimensions of the fire-box of this engine, it will be seen by the specification, are 60 inches length, $35\frac{5}{8}$ inches width, and 66 inches in height, the metal in the sides and back, and in the crown sheet, being $\frac{5}{16}$ inch in thickness, and that in the tube sheet $\frac{7}{16}$ inch. The grate area is therefore $60 \times 35\frac{5}{8}$ inches $= 14{\cdot}84$ square feet, and by the above rule the total area of heating surface should be $14{\cdot}84 \times 50 = 742$ square feet.

The actual heating surface is as follows:—

Heating surface in tubes $= 2\pi r \times l \times n = 6{\cdot}2832 \times 1 \times 132 \times 161 = 927{\cdot}2956$ square feet.

Heating surface in fire-box. Back end, 2·9687 feet × 5·5 (height) — 1·3893 sq. ft. (area of door) = 14·9366 sq. ft. Front end, 16·3259 — 3·5098 (area of tubes, $\pi r^2 n$) = 12·816 sq. ft. Sides, $5 \times 5{\cdot}5 \times 2 = 55$ sq. ft. Crown sheet, same as grate area, 14·8435 sq. ft.

The area of heating surface in the front tube plate is equal to the area of the cross-section of the shell, diminished by the area of the tubes, or 12·5664 — 3·5098 = 9·05 sq. ft., and neglecting this, since it is practically of no value as heating surface on account of the comparatively low temperature of the gases in the smoke-box, it being regarded as doing no more than to maintain the heat already in the water, the total heating surface may be expressed as follows:

Total heating surface in fire-box,	97·596 square feet.
" " " in tubes,	927·295 " "
Total heating surface in boiler,	1024·89 square feet.

(To be continued.)

TRIAL OF THE PUMPING ENGINES AT LAWRENCE, MASS.[1]

By THERON SKEEL, C. E.

The report of the trials of these engines,[ii] is of great interest to the engineering profession, and to all interested in the problem of the water-supply of large cities, particularly as it may be compared with that of the pumping engines at Lynn, Mass.[iii]

The engines in the two cases were of nearly the same size, and delivered almost exactly the same volume of water to nearly the same height. They were designed by the same engineer (Mr. E. D. Leavitt, Jr.), and erected by the same contractors. The experiments were made by the same gentlemen, in the same manner, and the records are sufficiently full in each case to give an intelligent understanding of the results.

A criticism of the report of the Lynn engine was published in the *Engineering and Mining Journal*, in March, 1876. The object of this paper is to compare the results of this experiment with those deduced from the records of that at Lynn, and to see how far the one verifies the other.

The duty of the engine at Lynn, as computed by Mr. R. H. Buel and the writer, by crediting the engine with the actual volume of water delivered (the pressure against which it pumped, being that which it was supposed would have been indicated by a correct pressure-gauge located at the level of the water in the pump-well, and connected with the force-main beyond the pump + one pound, which was an allowance for the supposed resistance of the passages between the well and the pump), and charging it with the weight of the combustible portion of the coal actually consumed + one-fifth of that weight (being an allowance for the ashes and refuse usually found in commercial anthracite coal), was 87½ millions for 100 lbs. of commercial anthracite.

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[1] From the *Engineering and Mining Journal*, November 25, 1876.

[ii] JOURNAL OF THE FRANKLIN INSTITUTE, vol. cii, p. 312.

[iii] JOURNAL OF THE FRANKLIN INSTITUTE, vol. xcvii, p. 29; vol. xcviii, p. 404; vol. xcix, p. 48.

The coal used in the experiments at Lawrence was "Cumberland," having 4 per cent. of ashes and refuse. A considerable number of experiments on anthracite and semi-bituminous coal, including "Cumberland," made by the United States Navy Department, and published in "Experimental Researches in Steam Engineering," by B. F. Isherwood, and elsewhere, have shown that the effect of the combustible portion of these coals when burned in the furnaces of steam boilers, similar to those at Lawrence, are *sensibly equal*. If there is any advantage, it is in favor of the semi-bituminous combustible, and the engine at Lawrence will certainly not lose anything by assuming the combustible to have been equal to that at Lynn.

In the report of the experiment at Lawrence, the Board of Experts have quoted paragraphs from their letter of instructions from the Water Commissioners, and have explained how the experiments were made, and how the calculation of what was termed the *duty* in those instructions was made.

The instructions appear to have been (so far as the points to be criticised in this paper are concerned) briefly as follows:

1st. To measure the water actually delivered by the pump.

2d. To ascertain the pressure in the rising main, near to the pump, by a correct pressure gauge.

3d. To weigh the Cumberland coal supplied to the furnaces of the boilers during an interval of forty-eight hours, said interval to commence at any time they might choose, the engines having been previously running uniformly, and the fires in good condition.

4th. To compute the "duty" by crediting the pumps with the weight of water actually delivered + 5 per cent., with the height equivalent to the pressure shown by the gauge + the statical height of the gauge above the surface of the water in the pump-well + one pound, and by charging the engine with the weight of coal actually fed to the furnaces.

It is not necessary to point out that the quantity called the "duty" when computed in this way, does not resemble the duty as ordinarily understood in any way whatever. The duty as ordinarily understood is the useful work done by one hundred pounds of coal, the useful work being the weight of water delivered by the pumps, lifted to a height equivalent to the pressure in the pipe through which the pump delivers. The experts in this case were required to measure the volume of water delivered and the pressure resisting it, and then to

declare that the pump had delivered 5 per cent. more water against one pound more pressure than their experiments showed.

One will not deny the propriety of an inspector cutting an inch off from the end of his yardstick before he measures a roll of cloth, provided the buyer and the vender direct him to do so, but care should be taken that the transaction is not placed on public record as an equal number of *standard yards*.

The allowance of 5 per cent. of the volume of water was ostensibly made to "allow for the loss of action" in the pump. In one experiment the pump delivered about 95¼ per cent. of the piston displacement, and the allowance of 5 per cent. increased this to 100¼ per cent. of the piston displacement, so that there is in this case the anomaly of the pump being credited with more water than it could hold.

The allowance of "one pound" was also made to allow for the "friction of the pipe and bends" between the well and the pump. In this case there were no such pipe and bends. The pump had an open bottom and was set directly in the well, the water in the well surrounding the pump barrel and the surface being considerably above the suction valves in the pump. The gauge was placed in the air-chamber of the pump, and thus measured the pressure of the water before it had been reduced by any friction except those of the pump-valves and passages. There would appear to be no more reason for adding one pound than for adding one hundred.

In computing the "duty" according to the instructions already quoted, the board would appear to have made one slight error. The specific gravity of the water was determined to be, by experiment, 1·005, distilled water at 60° being 1·000. From this the board computed correctly the weight of a gallon to be 8·38 pounds, but in computing the hydrostatic head, equivalent to the pressure of 75·85 (being the pressure shown by gauge + pressure equivalent to height of gauge above surface of water + one pound), they neglected to consider the actual specific gravity of the water, but assumed the greater height corresponding to a liquid having a specific gravity of 1·000. The error from this cause is nearly one-half of one per cent.

The engines were a pair of compound beam engines, coupled at right angles to a crank shaft and having one fly-wheel for both engines. Each engine consisted of a high pressure and a low pressure

cylinder at opposite ends of a working beam, and one "bucket and plunger" pump. Each engine had its own air pump, feed pump, and steam pipe, and the pumps delivered through separate water mains which united seventy-five feet from the engine-house. It is presumed there was a stop valve in each of these branch mains. The pumps had open bottoms, and stood directly in the pump well, the water surrounding the pump barrel and rising up considerably above the suction valves. The steam cylinders were steam jacketed on the sides and lower heads, the water of condensation from the jackets returning (it is presumed) directly to the boilers after being measured in the feed water tanks. There were two boilers of the locomotive type, the products of combustion passing first through the tubes and then returning through a brick flue under, and in contact with, the lower part of the shell of the boiler. The pump valves were the "Cornish Double Beat" type.

The Board of Experts made two sets of experiments, the one for economy being two runs, one of 22 hours, the other of 35 hours, with an interval of three hours between. The engine was stopped during one and a half hours of this time to repair "the pipe which had been inserted into the pump chambers for the taking of indicator cards" which had blown out. During these two runs the engines were uncoupled (it is presumed in such manner that all parts of the engine not in use, except the crank shaft and crank, were at rest) and one engine only run. A portion of the grate surface in each boiler was bricked off and both boilers were used. The water delivered by the pump was measured by a weir, and the pressure in the air chamber of the pump, together with the elevation of the gauge above the surface of the water in the well, which varied a little during experiment, noted every hour. The feed water (inclusive of that condensed in jackets) was measured in a tank, the coal fed to furnaces weighed, and indicator cards taken from the steam cylinders and various pressures and temperatures. The ashes withdrawn from the furnaces were also weighed.

The third experiment, being for capacity, was made with both engines and boilers (the bricks from the grates having been removed). That experiment lasted 35 hours, and was made in the same way, except that no indicator cards were taken from the steam cylinders.

The *nominal duty*, as computed by the Board, was:

Economy test (average), . .	96,186,979
Capacity test, ...	not computed.

If this result is reduced one-half per cent. to allow for error in computing height equivalent to pressure shown by gauge, the resulting figures (being a quantity computed as instructed and called in contract *the duty*) will be $95\frac{7}{10}$ millions.

There was an air cock on the suction pipe intended to admit air to the pump, but it is inferred from the language of the report that *this cock was not opened during these experiments.*

Comments upon the details of the report, in their natural order, will be as follows:

Coal.—The coal was "Cumberland," said by the Board to have been of good quality. Two kinds were used during the economy trial, the second kind being substituted in hopes of an improvement in the evaporation, but without success. The proportion of ashes and cinders was $3\frac{8}{10}$ per cent. Ordinary commercial Cumberland coal yields from 10 to 12 per cent. of ashes and refuse when burned in furnaces similar to those at Lawrence, tended by ordinarily skilled firemen.

Rate of Combustion.—The combustible portion of the coal was consumed at the rate of $\frac{16}{100}$ of a pound per square foot of heating surface per hour in the economy trials, and $\frac{26}{100}$ in the capacity trials. The temperature of the gas leaving the boilers was in the first case below the temperature of the steam, and in the second case varies from 20° cooler to 70° hotter than the steam. The low temperature of the gas may be have been caused either by leakage of air into the flues or by radiation of heat; in either case the economy of the boiler in the first experiments would have been improved by an increase of the rate of combustion until the gas was as hot as the steam. One would expect that the evaporation would be better in the capacity trial than in the economy. The actual results were in pounds of water evaporated from 212° by one pound of combustible:

Economy trial, ...	10·1
Capacity trial, ...	10·3

The engine, therefore, did not have any advantage in using two boilers during the economy trial.

Mean Pressures in Cylinders.—The mean indicated pressure as given in the report in the high pressure cylinder during the economy trial was 53·74 pounds, and on the low pressure 10·22 pounds. All of this pressure, except that necessary to overcome the friction

of the engines and of the bucket and plunger of the pump, must be balanced by the pressure of the water in the pump cylinder. The experiments on the similar engine at Lynn indicated that 2 pounds per square inch on the low pressure piston was sufficient to overcome all friction of machine and to work the feed and air pumps. Making the same allowance here, the unbalanced pressure transferred to the pump bucket was 84·7 pounds per square inch of pump bucket, while the pressure shown by the gauge on the air chamber + the statical head from the gauge to the level of water in the well was 74·84, showing that the pump required nearly 10 pounds per square inch of bucket to overcome the resistance of the valves and passages in the pumps, or 13 per cent. of the useful work.

Friction of Water in Main.—A comparison of the hydraulic head as indicated by gauge and of the statical head shown by preliminary survey shows the friction of the whole length of main from the pump to the reservoir.

	Head in feet.		
	Hydraulic.	Static.	Difference.
Economy trial, . . .	172·0	168·7	3·3
Capacity trial, . . .	176·4	169·7	6·7

The mean velocity of the water through the pipe in feet per second was, during the trial for economy, $1\frac{57}{100}$, and during that for capacity, $2\frac{56}{100}$. The loss of head from friction would theoretically be proportional to the squares of these numbers, or as 25 to 65.

Calculation of Friction of Water in Main.—The friction of the water in the short branch mains, 75 feet long, may be disregarded as insensibly small. The friction of the water in the long main during the capacity experiment, when the pipe was receiving 4 discharges from the pump each revolution, or 65 per minute, and the velocity therefore sensibly constant and $2\frac{56}{100}$ feet per second, may be computed from the formula given in Rankin's *Civil Engineering*, page 678, edition 1867, and for both cases, will be found to be in feet of water:

Economy trial, ... = 2·2
Capacity trial, ... = 4·2

being about $\frac{1}{3}$ less than that found by experiment in each case. The difference being $2\frac{1}{2}$ feet in the capacity experiment, and $1\frac{1}{10}$ feet

in the economy, may have been absorbed in overcoming the friction of the bends and of two sets of gates in the main.

RESISTANCE OF VALVES.—This was found to be from difference of steam pressure on steam pistons and water pressure shown by gauge in air chamber very nearly 10 pounds acting on the whole area of the bucket during one-half a revolution, from which it would appear that the force required to drive the water through the pumps, including the resistance of valves, was nearly 7 pounds per square inch, or 3 pounds for each valve. In the engine at Lynn, by the same builders, this force was only about 2 pounds, or less than one pound for each valve. The dimensions of the valves are not given with sufficient detail to compute the force required to lift them, but it may be inferred that the annular area tending to lift the valve was at Lawrence 23 sq. in., and at Lynn 60 sq. in. If the valves should weigh 100 pounds in each case the force required to lift them would be $4\frac{1}{4}$ pounds at Lawrence, and $1\frac{2}{3}$ pounds at Lynn. These figures serve to show that the additional resistance at Lawrence might be entirely due to the peculiar construction of valves.

The object in substituting "double beat valves" for disc valves was undoubtedly to obtain a greater opening for the passage of water, and thus allow it to pass through the pumps with less resistance. The construction of these valves entirely defeated that object, for the head required to open them (3 pounds) was sufficient to have forced all the water pumped through a single orifice 10 inches in diameter, being very much smaller than it would have been necessary to use with disc valves.

NOTE.—This condition of affairs appears to be not unusual in pumps using valves of this description. In the report of Citizens' Committee of Chicago, 1875, I find the pressure required to open valves (being the difference between the indicated pressure in the pumps and that shown by gauge outside) was 6 pounds for each set of valves. The valves in that case had almost identically the same dimensions as at Lawrence, namely, $15\frac{1}{16}$ inches diameter of outside of lower seat and $12\frac{3}{8}$ inches diameter of inside of upper seat. The effect of this large resistance was to reduce the useful work nearly 25 per cent.

WATER CONDENSED IN JACKETS.—This was found to be by an experiment made afterward, when the steam in the boiler was from 70 to 75 pounds, at the rate of 339 pounds per hour. During the experiments on the engines the steam averaged 90 pounds. Probably

the steam condensed during the experiments was at the rate of 360 pounds per hour.

DUTY.—I estimate the duty per pound of combustible, calculated on the actual volume of water delivered, on the pressure indicated by the gauge + the statical height of the gauge above the surface of water in well during test for *economy:*

$$27{,}650 \times 74{\cdot}85 \times 144 \div 3{\cdot}14 = 94\tfrac{9}{10} \text{ millions,}$$

and during test for *capacity:*

$$45{,}200 \times 76{\cdot}73 \times 144 \div 5{\cdot}287 = 94\tfrac{1}{2} \text{ millions,}$$

the mean of both being $94\frac{7}{10}$ millions, from which it may be computed that with commercial anthracite coal having $\frac{1}{6}$ ashes and refuse, the duty would be $78\frac{1}{10}$ millions. This is the actual *commercial duty* of the engine as shown by these experiments.

COMPARISON OF ENGINE AT LAWRENCE WITH ENGINE AT LYNN.—A careful comparison of the performance of the engine at Lawrence with the engine at Lynn will show as follows:

	Lawrence.	Lynn.
Pounds of water evaporated from 212° by one of combustible, ...	10·1	12·2
Pounds of water per indicated horse power per hour, ...	14·4	16·8
Pounds of combustible per indicated horse power per hour, ...	1·64	1 60
DUTY.—Calculated on the actual volume and pressure of water and for 100 pounds commercial anthracite having $\frac{1}{6}$ ashes and refuse (millions), ...	$78\frac{1}{10}$	$87\frac{4}{10}$

It appears that the boilers at Lynn were a little more economical than those at Lawrence, but that this advantage was nearly overcome by the economy of the engine at Lawrence being greater than that at Lynn (probably on account of the higher steam pressure and greater expansion), leaving the cost of an indicated horse power in combustible nearly the same in each case. The engine at Lynn only lost 9 per cent. of the useful power in overcoming all resistances of the engine and pumps, while the engine at Lawrence lost 18 per cent., the proportion of the indicated power utilized being, at

Lynn, ...	92 per cent.
Lawrence, ...	84 "

The engines and pumps (except the valves) were almost identical in each case. The chief cause of difference, therefore, was probably in the valves in the pumps.

SACCHAROMETER OR POLARISCOPE OF M. LAURENT.

Translated for the JOURNAL OF THE FRANKLIN INSTITUTE,

By ROBERT BRIGGS, C. E.

From the French of M. l'Abbé Moigno [*Les Mondes*, 16 Novembre 1876].

This new saccharometer has been arranged from an altogether practical point of view, so as to make the manipulation of the instrument as simple as possible, and yet preserve all desirable precision; and this result has been attained by a novel construction of the burner and its "*cup*," which gives a much more intense light than proceeds from ordinary burners, burning satisfactorily under low pressure, and not demanding any more than the usual quantity of gas.

A sketch view of the apparatus is shown by Figure 1, which is a longitudinal section, in elevation, except that the arms *J K*, shown vertical in the figure, are horizontal in actual construction.

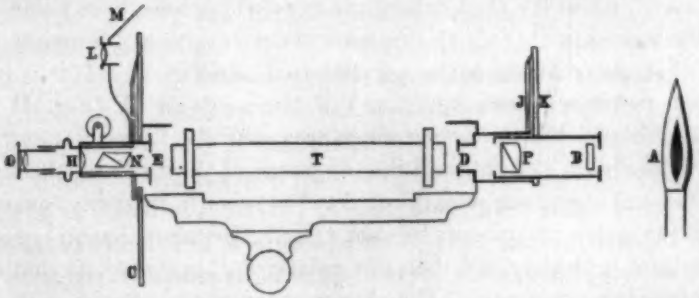

Figure 1.

A. Monochromatic *yellow* flame, placed at an invariable distance from the instrument (supported by a fixed standard shown in Fig. 6). *B*. Diaphragm containing a plate of bichromate of potash, for the purpose of absorbing the violet and blue rays contained in the flame, and permitting the useful yellow rays to pass intact. *P*. Double refracting prism, within which the second image is thrown aside and intercepted by the diaphragms. *D*. Diaphragm carrying a thin plate of quartz *parallel* to the axis, *the thickness of which is a half wave*, for the yellow rays. *E*. Diaphragm. *N*. Nicol analyzer. *H*. Object glass. *O*. Concave eyepiece, forming with *H* a Gallilean system of lenses. *T*. Tube containing the solution to be examined. *C*. Divided circle, having one or two sets of division; the one especial for sugar, and the other in half degrees of the circle, for substances of any power of rotation whatever. *L*. Eyepiece to read the divisions. *M*. Mirror which reflects the light from the burner *A* upon the divisions, and avoids the necessity of another light.

The system of polarization will be seen to present a novel optical arrangement. It is composed of two distinct parts: the double-refracting prism P, which can be rotated to a small extent by the arm K, and the diaphragm D with its half plate of quartz. Figure 2

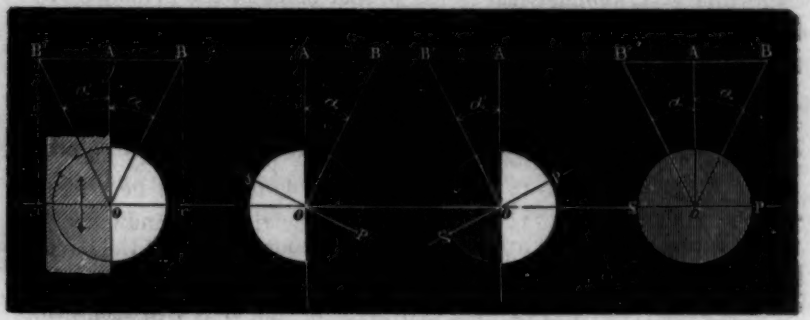

Fig. 2. Fig. 3. Fig. 4. Fig. 5.

represents the diaphragm D of the Figure 1 enlarged, as it will appear in the instrument. The left half is covered by the plate of quartz, the axis of which is parallel to the line of separation $O\,A$, and the right half, which is naked, allows the rays, which have been polarized by the polarizer P (Fig. 1), to pass without deviation. Suppose the plane of polarization to be parallel to $O\,A$ (Fig. 2). If it is permitted to remain unchanged, and if the analyzer N (Fig. 1) be turned, there will be a passage made progressively, from total extinction to maximum of light, and the two halves of the disc will, throughout these changes, one remain equal to the other in intensity, exactly as if the plate of quartz did not exist. The plate remaining unmoved, let it be supposed that the polarizer P is turned, so that the principal ray coming to $O\,B$ makes any angle whatever, α, with the axis $O\,A$. It follows then that the vibration accomplished within the plane represents by its trace $O\,B$. This vibration represented in its length by $O\,B$, may be decomposed into two others, the one $O\,y$, parallel to the axis $O\,A$ of the plate, and the other $O\,x$, perpendicular to this axis. This vibration passes to the right hand without deviation, but on the left hand it will be deviated by the plate. The ordinate $O\,y$, parallel to the axis of the quartz, does not change its sign, but the abscisse $O\,x$, which is perpendicular to it, does change its sign, and passes to $O\,x'$ or 180°; since the plate of quartz has the thickness of a half wave, it follows that on the left hand,

the resulting vibration will be to OB', and makes with the axis OA, an angle α' symmetrical and equal to α. The purpose of this plate is then seen to be, to move to the left a part of a principal ray OB, which it places in regard to the line of separation OA, symmetrical to the proper place of the principal ray OB on the right hand. If the polarizer is allowed to remain fixed in this position, and the analyzer be turned so as to bring the principal ray SP perpendicular to OB, Fig. 3, there will be a total extinction on the right side, but a partial one on the left, appearing as shown in Fig. 3. Reciprocally, if the principal ray SP of the analyzer be perpendicular to OB, Fig. 4, there will be a total extinction for the left side, but partial for the right, as indicated in Fig. 4. Finally, if the principal ray SP of the analyzer be perpendicular to OA, Fig. 5, there will be a partial extinction on both sides and equality of shade, because $\alpha = \alpha'$, and thus will result the appearance, Fig. 5. If, however, the analyzer is permitted to remain fixed in this last position, and the polarizer now be turned, so that the principal ray shall make angles, varying from 0° to 45°, with OA, the two half discs remain always equal in intensity one with the other, of shade; but the two will change, progressively, their common intensity in passing from total extinction to the maximum of illumination. In other words, if the instrument be regulated to zero, that is, to equality of shade, and the polarizer be turned, no change in the equality of shade will occur, in consequence of being in the zero position, but solely a change of intensity, common to the entire disc, which will present the appearance of a circular opening, more or less clear and distinct. But if, after having thus brought the polarizer to make any angle whatever (except the zero degree) with OA, and leaving it fixed in the last position, the analyzer shall be turned to a slight angle, either to the right or to the left of SP, Fig. 5; then, immediately, the equality of shade of the two half discs is lost, one grows deeper and the other more clear; this sudden change allows the determination of the position of the analyzer with great precision, and of the position of the zero of the instrument, when there is no substance for examination interposed. If any substance possessing the rotary power be interposed, it destroys the equality of shade of the half discs; and upon turning the analyzer as much as is necessary to re-establish this equality, the angle of

rotation to which the analyzer has been turned, indicates the rotary power of the substance. In this way this instrument gives a very simple, general solution of the question. That is, the angle of the principal rays from each of the two halves of the diaphragm can be made variable at will, and this new optical combination permits the study of different angles easily and rapidly within the limits of comparison; and, finally, to determine which is best to be taken in the case under consideration.

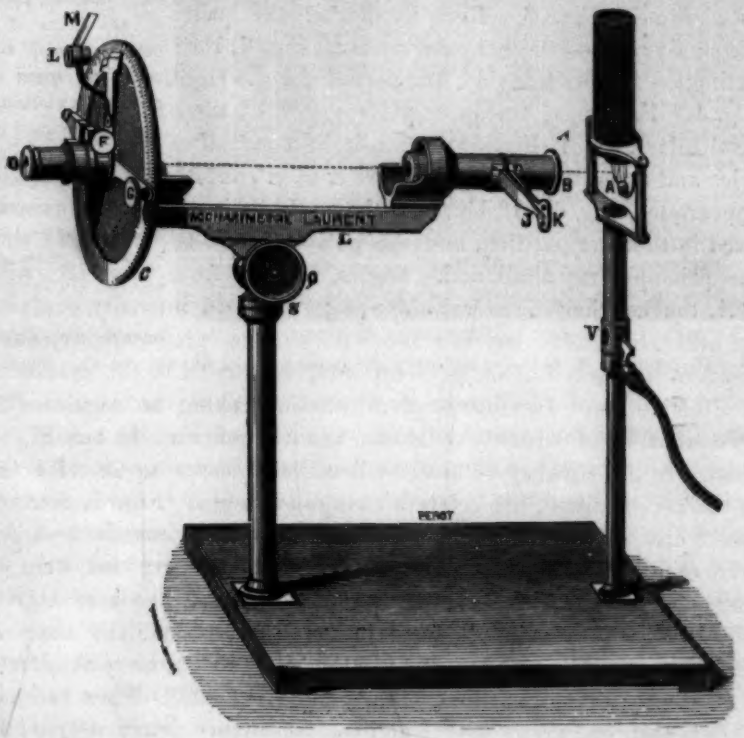

Fig. 6.

Fig. 6 is an elevation of the complete instrument in perspective. The reference to letters in description of Fig. 1, will explain more fully the purpose of the several parts; the parts not designated on Fig. 1 are: *G*, button for pinion to move divided circle; *F*, adjusting screw for vernier; *R*, tube containing the analyzer and object-glass, axis of motion effected by *F*; *Q*, button of clamp-screw, to give the horizontal adjustment of the instrument; *S*, pivoted axis, for allowing the instrument to be swung in a horizontal plane.

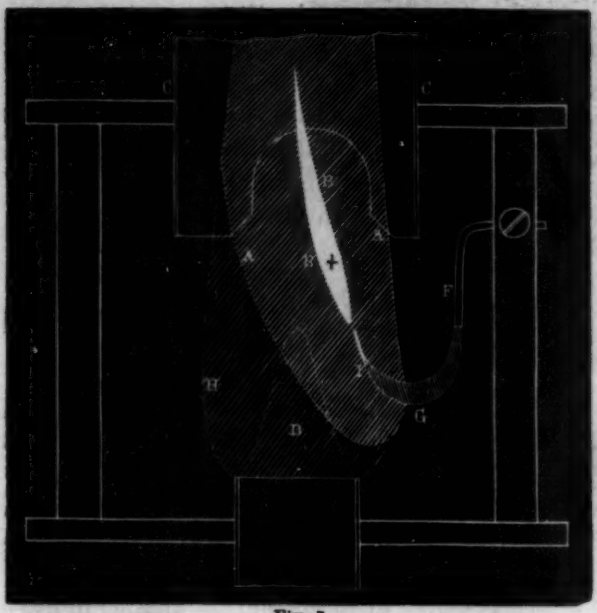

Fig. 7.

Fig. 7. *A*, yellow flame of ordinary burner; *B*, luminous part—supplementary and very intense; *C*, chimney, rendering the flame fixed; *H*, violet flame, high, large, and excessively hot; *D*, flame in the form of a cone, greenish and cold; *G*, *spoon* or *cup* of thin platinum plate, supported by a strong platinum wire, *F*. The burner *A* will operate with 0·08 to 0·12 in. of water pressure, and can also be used by partly closing the burner cock, with 0·4 inch pressure, so that the ordinary gas pressure will answer for this burner.

The position of the burner in place, for making an experiment, and the view of the several adjuncts, is shown on Fig. 6; but Fig. 7 exhibits an enlarged section of the flame, and serves to describe the manner of its operation. In the platinum cup *G*, Fig. 7, there is placed a grain of salt, which, when fused by the intense heat of the flame *H*, mounts, by capillarity, the length of the grooved strip or border *I*, which is very hot; and the vapor of salt produces at *B* a narrow flame, exceedingly brilliant, even more brilliant than is absolutely requisite in using the instrument. But little salt should be put in at a time, and the supply frequently made. When there is too much or too little salt in the cup, the intense luminous part of the flame is impaired. It is very essential, for obtaining the best results, to locate the cup at the place indicated on Fig. 7; that is, in the middle of the flame, but well under the side, the raised edge being in the violet flame. The purpose of the plate of bichromate of potash, *B*, Figs. 1 and 6, is to purify the yellow flame by absorbing completely the violet rays, as well as the blue and part of the green, which exist in the flames *D* and *H*, that proceed from gas burnt with a current of air; and it does this effectually, without taking up any of the useful yellow rays.

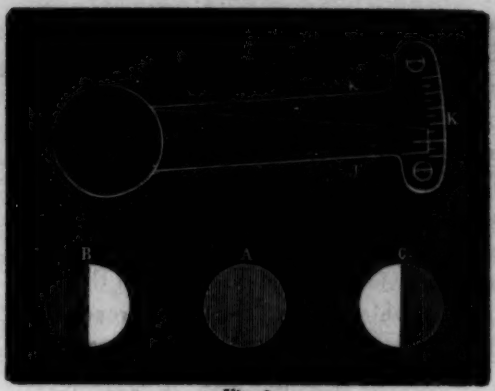

Fig. 8.

The operation of the instruments is as follows: The lever *K*, Figs. 6 and 8, being raised to contact with its stop; a tube, *T*, Fig. 1, of eight inches in length, filled with distilled or filtered water (not boiled), is placed in the instrument, and by means of the clamp button *Q*, Fig. 4, which is screwed up moderately, and the swing adjustment *S*, Fig. 4, it is directed against the flame *A*, as nearly as possible; (afterwards, this adjustment of direction is exactly made). The eyepiece *L* is adjusted so as to allow the division to be seen distinctly. These divisions should be well illuminated by the mirror *M*, which receives its light from the flame *A*, because it is preferable to operate in obscurity. The zero of the vernier is moved to about the 7th division in hundredths of sugar (or about $1\frac{1}{2}°$, if the scale of degrees is taken), either to the right or left; which motion is effected by means of the clamp screw *G*. Following this, the eyepiece *O* is looked into, and there should be the appearance *B* or *C*, Fig. 8; that is, there should be seen a disc, divided in two halves, the one clear, a bright yellow, and the other a yellowish black. The tube *O*, of the eyepiece, is drawn out or moved in, until the separation of the halves is nicely indicated, and the edges of the diaphragm outside of the disc do not appear. Later on it is very important to establish carefully the equality of shade; the better this is done the more sensitive or accurate will be the observations of the instrument. It is well to notice here, by way of testing this thin plate, while the edge is perfectly clear and sharp, that the two half discs are not separated either by a black line, or by a line black and white; they are rigorously tangents, and the least difference of shade between them is appreciated; when making an equality of shade (*A*, Fig. 8), they have no line of separation whatever. This detail has a great practical importance and certainly increases the relative sensibility of the saccharometer.

The instrument possesses in the two axes of rotation at *O* and *S*, the means of directing it towards the light. From time to time it

should be made certain that it is well pointed to the maximum of light and this adjustment must be carefully maintained.

Having thus disposed the instrument, the arm *L* is to be taken by the left hand, while the right hand is employed in holding the tube *R*, Fig. 6, between the thumb and index finger, when applying the eye to the eyepiece *O*, by little movements, up or down, to the right or to the left, the disc is brought to appear of the most uniform shade. The final adjustment is performed by use of the button *G*, which brings the zero of the vernier, to coincide with exactness to the division which may be chosen, after which the instrument is readjusted by means of the button *F*, which is provided only for this purpose, until the two sides will be seen (as at *A*, Fig. 8), of a gray yellowish shade, quite equal in intensity. [The button *F* turns in the reverse direction, as the dark side clears itself, or the light side becomes darker.] The exact place of equality of shade has been found when, by turning the button *G* alternately to the right or left, by little movements, there passes successively the appearances *B* and *C*, Fig. 8, when fixing the point of arrest definitely at the appearance *A*. The instrument is then adjusted for its zero point, but it should now be verified; for this displace the index by the button *G*, and by means of the same button reproduce the equality of the shades. If the adjustment has been carefully done, it will be easy, by regarding the traverse of the arm *L*, to re-find the zero of vernier in coincidence with the division. If otherwise a slight touch of the button *F* in one direction or the other, will produce the coincidence of zero, and allow the establishment of the equality of shades by means of the button *G*, and then only the instrument is well regulated for one operator *solely*.

The solution of sugar being interposed (in place of the water in the tube), the two sides of the Fig. 8 will become clearer, and at the same time more unequal in shade. The button *G*, Fig. 6, should then be turned in such direction, that the least clear side continues to become darker until nearly black; pursuing in the same direction this dark side shortly clears itself, and the clear side becomes black almost immediately; the proper point will then have been passed; on turning slowly backwards the equality of shade is established by a series of oscillations of the button *G*, becoming smaller and smaller as the appearance *B*, Fig. 8, changes to that of *C*, before finally stopping at that of *A*.

If the vernier has turned to the right in its departure from zero, the rotary power is right hand, as is given with cane or beet-root sugar, diabetic sugar, glucose, right hand quartz, etc. If the vernier has turned to the left, the rotary power is left handed, as exhibited by uncrystallizable sugar, inverted sugar, left hand quartz, etc.

Oftentimes in the industry of sugar, the juices or syrups are colored; these being placed in the instrument (the lever *K*, Figs. 6 and 8, being raised), are so dark, that nothing can be seen, and that it is thus impossible to do anything with them. The same obscuration occurs with other saccharometers. This instrument now offers a means for obviating this defect not possessed by any other, in permitting the passage of more light through it, by lowering gradually the lever *K*, as much as may be necessary. The enormous advantage of being able to use the saccharometer with an approximation sufficiently close for all purposes, in cases where all others fail, will be appreciated by those who have knowledge of, or use for, these instruments. It is possible to avoid in this way the effect of discoloration of liquor or syrup by bone-black, an operation heretofore long and subject to error, from the quantity of sugar retained by the black itself.

Any liquid being given, one can always, with this instrument, choose that angle which will give the best result, and practice shows that this angle varies with the coloration of the liquid. To effect this, the horizontal arm *J*, Fig. 8, has a point or mark, and the other, *K*, has divisions, forming a scale (in this instance in millimetres, but the size of the divisions are of no consequence, only that they had better been in degrees) to serve for indication of the movement, by which the best result for a certain coloration can be determined and made note of.

If it is desired to verify the result of any experiment, by another operator, it is necessary that the latter should re-make for himself all the manipulations, unless he has the same view or peculiarity of vision. It is sufficient to re-take the zero with distilled water and to examine and verify the equality of shades with the liquor.

The perfected burner which has been described, is not restricted in its use to saccharometers; but is also applicable in all cases where an intense monochromatic light is desired. Amongst other instances of this kind, its application to the spectroscope would be very happy. The saccharometer of Mr. Laurent (grand-son-in-law of M. Soleil) is an excellent practical instrument, which it is not known how to recommend too highly.

TOUGHENED GLASS:

NOTES ON ITS MANUFACTURE.

From *The Practical Magazine* of London, for October, 1876.

[Continued from Vol. cii, page 374.]

Good management of the melting-ovens is of capital importance; the perfect homogeneity of the material is also one of the conditions of success. Glass that has remained a long time in the crucible, and that has thus maintained for too long an elevated temperature, tends to give way to a commencement of devitrification; in this state it will break in the bath. The work also should proceed rapidly and never be interrupted when it is desired to utilize the great part of the material contained in the crucible. A glass which presents a striated appearance—a defect likely to be produced if the management of the oven is not regular—will not adapt itself to toughening.

Apparatus for Toughening Table Glass.—The grease-bath is contained in a cylindrical iron tub, placed on the floor of the factory, and as near as possible to the working-hole. This tub is 0·75 m. high and 0·60 m. in diameter. For convenience in carrying, the height should not exceed that of the opening of the working-hole above the ground. The capacity, limited by the necessity of being able to easily displace the tub in the factory, should be sufficient for it to contain and toughen during two or three consecutive hours pieces of the least dimensions. If the tubs are placed at a depth in the ground, and made to move upon rails in trenches, their capacity and depth may be increased and at the same time their displacement rendered more easy. It is necessary for this to have the working-holes heated by furnaces independent of those that contain the crucibles, to which access must be entirely free. In the tub is fitted a basket of 0·50 m. high and 0·55 m. in diameter; this lining, being a wire trellis of large mesh, is elastic, and sustained by iron braces. It is into these baskets that the glass is thrown at the moment of toughening.

Manner of Toughening Table Glass.—The object being very uniformly heated, the workman takes it from the working-hole, plunges

it rapidly into the bath, and after detaching it from the pontil by a slight blow on the side with a piece of wood, it falls to the bottom of the wire basket. This operation demands great supervision, and on the part of the workman much care and attention. There are numerous precautions in detail to observe to avoid the malformation of the glass at the moment of immersion. These precautions vary with the form of the pieces, and each of them is a study in itself. Different apparatuses have been contrived to facilitate the operation.

A pouch of metal wire with a movable bottom is fixed inside the tub, and immersed from 0·30 m. to 0·35 m. in the liquid. Its use is to receive primarily those pieces which, by reason of their weight or of their form, might, by too brusque a fall, break the glass that is already at the bottom of the tub. There are some pieces, such as goblets, which are placed in the tub directly from the carrying rod without fear of breaking.

The toughening of water-bottles and similar vessels with necks presents a difficulty on account of the necessity of instantaneous introduction of the liquid into their interior. With the syphon a solution of this problem is found. The neck of the bottle is placed on the smaller branch of the syphon, which is elevated a half-centimetre above the surface of the bath. The confined air escapes by the tube, and the liquid takes its place, and at the same time, by a see-saw motion, the pieces fall to the bottom of the basket. A pump can be adapted to the syphon to extract the air from the bottle. By this means bottles with the narrowest of necks may be tempered. The toughening of objects made in several pieces has not hitherto been successful; the portions become detached in the bath.

Cooling, Cleansing, and Rinsing Toughened Crystal.—It is important to allow toughened crystal to gradually cool before removing it from the bath. To effect this, the tubs, placed on triangles, are removed from the working-hole and placed in a room in which a constant temperature of 40°—that of melting of grease—is maintained. In the course of four or five hours the baskets are taken from the tubs, and the pieces of glass taken out one by one and arranged to dry on sieves. The sieves are put into a stove, called the draining furnace, which is kept up to a temperature of 70°. In about two hours the glass is divested of the grease which had adhered to its sides. Taken from the stove, it is replaced in the large-mesh wire baskets, and these baskets are successively plunged into three

reservoirs—the first containing a bath saturated with caustic soda, and heated to 60°, the second containing water at 50°, the third, water of the temperature of the surrounding air. The glass, after it has been taken from the third reservoir, is perfectly rinsed; it is then dried, and taken to the warehouse, where it goes through a first sorting before being sent to the cutter. I will add here that toughened glass is cut and engraved more easily than ordinary glass.

When, instead of grease, a bath of oil is used, the pieces are allowed to cool longer before taking them to the tub; but the cleansing is much more expensive. They require to be treated with essence of turpentine.

Cost of Toughening Crystal.—The introduction of toughening into an existing glass-house is worked as follows for each furnace of three places:—1st. For staff, one more workman, called toughener, to each place; two porters to remove the tubs, and three men to take charge of the cleansing of the crystal. 2d. For plant, four tubs to each place, each containing 170 to 180 litres of grease; two or three pouches, and as many syphons; three iron reservoirs, of a cubic metre capacity, for cleansing and rinsing; a number of sieves and baskets for carrying the glass to the cleansing reservoirs.

A tub for toughening, with its accessories, costs from 100 to 120 fr.; grease costs 120 fr. for 100 kilogrammes. For a melting furnace of three places, comprising six crucibles to four working-holes, the expense of toughening crystal will amount in a month of 26 days to the sum of about 2,200 fr. That is:—

	Fr.
Six toughening, at 150 fr. a month,	900
Two porters for tubs, at 130 fr. a month,	260
Three men for cleaning, at 110 fr. to 120 fr. a month,	350
Loss of grease by evaporation and in the manipulation of the glass,	200
Fuel for the draining furnace, for the tubs for toughening and cleansing,	100
Soda for cleansing,	150
Wear and tear of apparatus and of the draining furnace, and interest on capital,	250
Total,	2,210

The loss occasioned by breaking and deformation of pieces in the bath is as yet of much importance, but every day will tend to dimin-

ish it with the improvements that may be brought to bear in the manner of toughening.

With these facts, knowing the exact number of pieces of the same model that can be made in a day's work, it will be easy to fix the price of the cost of toughening each object. Admitting 10 per cent. of loss and deformation, the price will be approximately:—

22—25 per cent. for goblets of all shapes.
30 " for gas glasses.
40 " for lamp glasses.
50 " for lamp globes.

Glass costs more to toughen than crystal—the glass being toughened in oil, and at a higher temperature, the loss of the liquid from evaporation is more considerable, and the cleansing of the pieces more expensive. The cooling of the bath being also more slow, continuous work requires a greater number of tubs to each place. Instead of four there should be eight or ten.—Translated from *Le Technologiste.*

Lectures on Technical Mechanics.—A course of lectures on this subject, intended to instruct practical men in the application of mechanical science to practice, will be given by John W. Nystrom, at the rooms of the Franklin Institute, on the Friday evenings of January, February, and March, 1877.

Mr. Nystrom will offer a course substantially like those given by Technological Institutions on the continent of Europe, in which he will commence at the beginning, and lead his hearers step by step to the higher applications of practical mechanics. "The only knowledge required on entering the course is simply arithmetic. The necessary geometry and algebra will be taught, together with mechanics, so as to enable students in the class to read understandingly scientific books on that subject."

No more useful course of lectures can be possibly offered to the practical workman, or to the amateur in mechanics, than this proposed by Mr. Nystrom, and it is hoped that he will have large and appreciative audiences. The tickets to the whole course are $3.00 each, for a single lecture 25 cts. They are for sale by the Actuary of the Institute, or at the door of the Lecture Room.

Chemistry, Physics, Technology, etc.

ON THE GROWTH OF THE ALKALI AND BLEACHING POWDER MANUFACTURE OF THE DISTRICT OF GLASGOW.

By Jas. Mactear.

Paper offered to the British Association for the advancement of sciences. Read before the Chemical Section, September 12th, 1876.

Introduction.—It has been considered that a slight historical sketch of the rise of the Alkali and Bleaching Powder Manufacture of Glasgow (which indeed was the birthplace of the latter article) would fitly take its place in a report upon the chemical industries of the district, on the occasion of the visit of the Association at this time.

In the search after the necessary data, so many curious facts and figures cropped up, that indulgence must be craved for the length of the communication, which, even as it is, far from exhausts the subject.

Part I.—Salt.

Intimately connected with the manufacture of alkali and bleaching powder is that of common salt.

The heavy duty on this article at the end of last and beginning of this century retarded for many years the development of the alkali trade.

The following details regarding the salt manufacture are interesting:

In the year 1798 (previous to the rise of duty which came into effect in the summer of that year), the quantity of salt manufactured in Scotland was 350,000 bushels of 56 lbs. each, or 8750 tons, produced by 118 pans distributed as below:—

Division.	Situation.	Pans	Division.	Situation.	Pans
Aberdeen	Patsoy	1		*Brought forward,*	51
"	Peterhead	2	Kircaldy	Kircaldy	2
"	Nigg	2	"	Dysart	7
Ayr	Maryburgh	1	"	Wemyss	7
Alloa	Limekilns	1	"	Methel	8
"	Craigflowers	4	"	Leven	3
"	Torryburn	1	Montrose	Montrose	2
Anstruther	St. Phillips	7	"	Usan	1
Borrowstounness	Corly Hall	7	Prestonpans	Prestonpans	6
"	Thistone	7	"	Cockenzie	11
"	Grangepans	5	"	Cuttle	2
"	Inverkeithing	4	"	Westpans	6
"	St. David's	4	"	Penkie pans	8
Irvine	Saltcoats	4	"	Duddingstone	4
Stranraer	Gladmock	1			
	Carry forward,	51		Total Pans	118

Produced annually, 350,000 bushels at 56 lbs. each = 8750 tons.

From this it would appear that each pan produced annually about 75 tons, or say 1½ tons per week.

The price was 3*s.* 3*d.* per bushel or 6*l.* 10*s.* per ton, duty inclusive, the latter being 1*s.* 6*d.* per bushel or 3*l.* per ton.

The additional duty now put on was 6*s.* 6*d.* per bushel or 13*l.* per ton, making the cost amount to 19*l.* 10*s.* per ton.

The duty in Scotland was much less than in England, the figures being in the year 1805—Scotland, 12*l.* per ton; England, 30*l.* per ton.

The following is a statement of the method and cost of manufacturing one ton of salt, dated September, 1806 :—

"At Mr. Cunningham's works at Saltcoats there are in operation "4 pans, each 18 ft. by 9 ft. by 1 ft. 9 in.; each pan requires three "men, or twelve in all.

"These men are paid at the rate of 1*s.* 1*d.* per cwt., exclusive of "house and fire.

"They keep their fire-places in order without any allowance, re- "pairing them with schistus or clay, got in the immediate neighbor- "hood. The schistus answers for brick, and they say much better. "They are not allowed for the time lost in repairing their boilers.

"The pans are of malleable iron of nearly ⅝ in. thick, supported "on malleable iron bars about 3 in. square, placed across under each "row of clink nails, say about 15 in. apart.

"A pan, with frequent repairs, lasts about five years, and costs "when new about 200*l.*

"These pans yield five castings of salt per week, weighing 10 to "11 cwts. each, agreeable to the strength of the sea water.

"In order to produce these 10 to 11 cwts. of salt, the pan is filled "three times till within four inches of the brim (they cannot be filled "more with advantage to the ebullition).

"The two first fills are boiled down till the salt begins to form, the "first down to within about one inch of the bottom, the second to "within about one and a half inches, and the last to about two and a "quarter inches, which consists chiefly of the pretty dry salt.

"This salt is then raked to the side of the pan, and thrown into a "square chest, where it is allowed to drain till a third casting is "ready to replace it, two chests being always employed.

"While in this situation it yields about 20 gallons of bittern, or "'pan oil,' as the workmen call it.

"In each pan there are four small round vessels of 8 in. by 4 in., "placed one in each corner, which, during the evaporation, collect "all the insoluble salts and impurities deposited during the process, "sometimes more or less, in proportion, it is said, to the weakness of "the water.

"*State of Charges by the ton weight.*

"Wages, ...	£1 1 8
"Coal dross, 162·192, say 180 cwts., at 1*d.*,	0 15 0
"Tear and wear, say, ...	0 10 0
"Rent, say, ...	0 4 0
"Cartage of coals, at ¼*d.* per cwt., . .	0 3 9
	"£2 14 5"

The manufacture of salt is still continued at Saltcoats, but on a different system, the sea water being employed to dissolve rock-salt obtained from Ireland, which gives a solution requiring much less evaporation than the old system.

This method is also carried out to a small extent in Glasgow.

The following table gives the prices of salt for chemical purposes in Glasgow from the year 1798:—

Year.	Price per ton.	Year.	Price per ton.
1798, . .	£13 to £18	1803, . .	£12 0 0
1800, . .	£12 0 0	1804, . .	12 0 0
1801, . .	No details.	1809, . .	19 0 0
1802, . .	"	1814, . .	11 0 0

Year.	Price per ton.	Year.	Price per ton.
1819, . .	£1 12 0	1849, . .	0 17 0
1824, . .	2 6 0	1854, . .	0 15 0
1829, . .	1 2 0	1859, . .	0 16 0
1834, . .	0 19 0	1864, . .	0 14 0
1839, . .	1 1 0	1869, . .	0 14 6
1844, . .	0 16 0		

At or about which price it has since remained.

The quantity of salt used for chemical purposes previous to the introduction of the method of bleaching by chlorine, must of course have been small. Marine acid, however, was made, and there is a tradition amongst the oldest workmen of the chemical works that it was produced (some years previous to the introduction of sulphuric acid about 1749) by the distillation of salt and earthy matter. That this process was actually in use is extremely probable, as it is described by the writers of the last century—"eight parts of clay or bolar earth to one of salt" being the mixture recommended, distilled in stoneware retorts.

Part II.—Sulphuric Acid.

The substitution of dilute sulphuric acid for sour milk in the old system of bleaching, which had the effect of reducing the time required by nearly one-half, gave rise to a demand for vitriol in considerable quantity, and to supply this demand a work was erected in 1749, at Prestonpans.

I have been unable to find any evidence of the manufacture of sulphuric acid in Scotland previous to this date.

As is well known, the first method of producing sulphuric acid was by the distillation of sulphate of iron or *green vitriol.*

This was followed by a method of burning sulphur under a bell glass moistened with water, and the acid (produced in very small quantity) is said to have been sold at 2*s.* 6*d.* per oz.

In 1740, MM. Lefèvre & Lémery proposed the addition of nitrate of potash to the sulphur, and suggested that the combustion could then be carried on in closed vessels. This idea was taken up in England by a Dr. Ward, who used large glass vessels holding about 300 litres, and containing at the bottom a small quantity of water.

A small capsule, supported on a stoneware stand, was charged with a mixture of one of nitre and eight of sulphur. This was set on fire and the neck of the vessel closed. After the combustion had ceased, fresh air was allowed to enter the vessel, and these operations were

repeated until the acid was sufficiently strong for concentration in glass retorts. This acid sold at about 2*s*. per lb.

Dr. Roebuck of Birmingham improved on this process by erecting a leaden vessel of about 6 ft. square as a substitute for the glass ones previously in use. This was in 1746, and works were erected by this gentleman and a Mr. Garbett, in the year 1749, at Prestonpans, on the east-coast of Scotland.

This, then, was the beginning of the sulphuric acid manufacture in Scotland. Other works were soon erected, and in 1797, there were in Glasgow alone at least six or eight different works.

In this year the question of the strength of the commercial vitriol seems to have received a good deal of attention, and a set of hydrometers were invented or arranged by a Mr. Foy, a chemist at that time engaged in bleaching operations.

The following is a note of the cost of manufacturing 950 bottles of vitriol (of 150 lbs. each).

"*Mr. M——'s business*, 1798."

25 tons Sulphur—say at £40,					£1000	0 0
7 " Nitre " 100,					700	0 0
Coals,					105	0 0
Wages and houses for men,					250	0 0
Tear and wear of utensils,					30	0 0
Rent and buildings,					70	0 0
Cartages,					40	0 0
					£2,195	0 0
142,500 lbs. O.V. at 6½*d*.,	£3,859	17	6			
Less discount at 10 per cent,	385	19	9			
					3,473	17 9
Profit,					£1,278	17 9

This gives nearly 64 tons of acid costing, say £32 per ton, and selling for, say £54 net cash.

Description of method of working then in use by Messrs. Bealy, Radcliffe, near Manchester:—

May, 1799.—"There were six chambers, 12 ft. by 10 ft. by 10 ft., "roofed like a cottage. They were placed in houses having openings "in the brick walls, leaving the lead to be exposed to the atmos- "phere.

"This is perhaps of more use in expediting the filling of the chambers with fresh air than in aiding condensation. Mr. Laird (a Glasgow manufacturer of the period) says that the hotter the chambers are kept the condensation is the more perfect.

"Each of these chambers has a valve, which is opened between the burnings.

"In them there are burned each week 1386 lbs. sulphur and 198 lbs. nitre, burnt in double pans, the larger above the lesser, and yielding 1800 lbs. of O.V. of 1·8 sp. gr. (equal to a produce of 130 per cent. on sulphur, with 14.28 per cent of nitre).

"Eight to nine inches of water on the floor of the chamber.

"The sulphur and nitre are mixed in the proportion of one of nitre and seven of sulphur.

"Of this mixture 8 lbs. are burned in each chamber every four hours. The mixture is burned on iron plates or trays, of which there are two sets only in each chamber (more not being found so productive), each set consisting of two plates, one placed over the other, about 3½ inches apart.

"The iron is of best quality and very thin, so that they heat quickly. They are supported on a frame, which can be drawn out at the door of the chamber.

"One pound weight of the mixture is put upon the lower plate, and three pounds on the upper plate.

"The plates being charged, the lower plates are first ignited, and when fairly lit, then the upper plates; the frame is then pushed into the chamber and the door shut.

"The whole will be finished burning in one hour.

"Charge again three hours after the burning is over, or once every four hours, opening the doors and valves a quarter of an hour beforehand.

"The plates to be cleaned each time.

"By keeping this going on, they in six weeks make their O. V. attain a gravity of 20 oz. (1·250 sp. gr.), when it is run off for concentration to 22 oz. (1·375 sp. gr.), when it is used for bleaching liquors, etc., etc.

"Having six chambers, therefore affords one for drawing off each week.

"*State agreeable to the above.*

"1386 lbs. Sulphur, at £22, ...	£13	12	3
" 198 " Nitre " 64, ...	5	13	1½
"Labor, ...	1	1	0
"Tear and wear, ...	1	1	0
	£21	7	4½
"Off for drawback on sulphur, at £6 12 8 per ton,	4	2	0½
"Producing 1800 lbs. O.V., costing, . .	£17	5	4

"Equal to 2½*d.* per lb. or 21*l.* 10*s* per ton.

"Interest on sunk capital omitted in this state."

The prevalent theory held at this time may be seen from the subjoined note.

"When sulphur is heated to 302°, it burns with a blue flame, and "the produce is chiefly sulphurous acid.

"When sulphur is heated to 570°, it burns with a white flame, and "the produce is sulphuric acid."

Numberless experiments were conducted with the view of being able to burn the sulphur at the proper degree of heat which should yield only sulphuric acid.

The fact that a quantity of nitrate of potash only equal to one-eighth of the oxygen required was sufficient for practical purposes, seems to have given rise to the most extraordinary ideas at this time.

The following calculations give a good illustration:—

"100 of nitrate of potash according to Kirwan, contains 41·2 of "nitric acid, 46·15 potash, and 12·83 water.

"The acid of nitre consists of 7 of oxygen and 3 of azote, hence "100 nitrate of potash contains 28·7 of oxygen.

"100 of sulphur, it appears from Kirwan, requires 140 of oxygen "to saturate it, or convert it all into sulphuric acid.

"100 acid, therefore, consists of 41·67 sulphur and 58·33 oxygen.

"Consequently 100 sulphur would require the oxygen of 525 of "nitrate of potash for complete saturation.

"When, therefore, the maker of sulphuric acid adds 10 of nitre to "100 of sulphur, he has only 2·8 of oxygen, which will saturate only "2 of sulphur.

"Now 10 of nitrate of potash contains 4·612 of alkali; that alkali "is converted into sulphate of potash, and requires for this 4·5 sul-

" phuric acid in that state in which it exists in the sulphate of potash " (it contains, by Kirwan, 45 acid and 55 potash). *That is, the potash " of the nitre takes more acid than is produced by the oxygen contained " in the nitre with its proper proportion of sulphur.*

" The nitre, therefore, used in the manufacture of sulphuric acid " does not produce *any* acid which the manufacturer can be the better " of. It produces no sulphuric acid in an uncombined state. The " only other purpose it can serve is to produce such rapid inflamma- " tion of the sulphur as will be productive of sulphuric instead of " sulphurous acid; *that is, it produces a white flame, and the temperature " of* 570°.

" Even with nitre, a great deal of blue flame is present, and con- " sequently much sulphurous acid formed, and this sulphurous acid is " all lost to the manufacturer, as it flies off in the operation.

" The manufacturer, at most, produces from 100 sulphur, 168 of " marketable oil of vitriol of 1·846 sp. gr.

" But 100 parts of sulphuric acid at this strength is equal to 89 at " 2 000, which Kirwan calls his standard acid, and 100 standard acid " is equal to 89·25 of acid, such as exists in sulphate of potash, or 100 " parts acid at 1·846 sp. gr. are equal to 78, as existing in sulphate " of potash.

" The manufacturer therefore only gets 125 6 acid, such as exists " in sulphate of potash, whereas 100 parts sulphur should produce 240 " parts of such acid, deducting 2 parts, which go to form the sulphate, " leaving 238 parts.

" These 238 parts are equal to 290 at 1·846 sp. gr., which ought " to be the produce, instead of 168.

" Hence only 55 parts of the 100 sulphur used, go to form sulphu- " ric acid, and 45 parts are lost.

" Some part of these 45 may indeed be impurities—allow 5 per cent. " on this account—still the manufacturer loses 40 parts in every 100 " of sulphur.

" These 40 parts are converted into sulphurous acid, and are lost."

The only way to prevent this is to burn the sulphur with a white flame, and by raising the temperature in which it is burnt to 570°.

At the Prestonpans Works in 1800, *they used, per* 112 *lbs. of O. V.*:—

100·8 lbs. of Sulphur, at 7*s.*,	£0	6	3
13·06 " Nitre, at 36*s.*,	0	4	2
All other expenses,	0	10	7
Cost delivered to purchasers,	£1	1	0

The selling gross price being about 60*l.* per ton. This is equal to a production of—say 198 per cent. acid, 1·84 sp. gr., with 13 per cent. nitre.

The size of these chambers was most likely the same as given in 1813, when they had 108 chambers, 14 ft. long, 10 ft. high, and 4½ ft. wide. In 1805 a work existed at Burntisland which employed no less than 360 chambers, each 8 ft. long, 6 ft. high, and 4 ft. wide, containing 192 cubic ft. each.

Water equal to 70 or 80 gallons (5 to 6 inches) was run on the bottom, and the charge was 1 lb. of a mixture of 1 nitre to 6 of sulphur every four hours, half an hour allowed for ventilation.

The burning was continued for ten weeks, in which time 36 chambers yielded 60 bottles rectified acid. This being the weekly produce of the works:—

Produce,	173 per cent. O.V. 1·84 sp. gr.
Nitre,	16 6 "

Many more such details might be given, but it will be more instructive to trace the development of this manufacture in the progress of the St. Rollox Chemical Works.

These works were erected in 1799, for the production of bleaching powder, a patent for which had been secured by Mr. C. Tennant in the previous year. Considerable quantities of sulphuric acid were required for this manufacture, and were purchased from the various local makers, from the Prestonpans Vitriol Company, and supplies were even brought from Halifax.

The price at this time being about 60*l.* per ton delivered.

The consumption increasing rapidly, chambers were erected at St. Rollox in 1803; these were six in number, and seem to have been 12 ft. by 10 ft. by 10 ft., costing to erect about 50*l.* each.

The house in which they were contained was of three floors, about 50 ft. long by 24 ft. wide—the upper contained the chambers, the next the glass retorts for concentrating the acid, and the lower the leaden evaporating boilers used in bringing the acid up to strength for the glass retorts.

The system upon which these chambers were worked, was that as already described as in use by Messrs. Bealy, and the quantity of sulphur burned was about 1000 lbs. weekly, with about 14 per cent. nitre.

Various modifications of this system were tried, chiefly to improve the yield by charging less often, until the question of how to deal with the residues became a serious one, and in 1807 a third plate was added, on which the residues, or "sulphur ashes," were reburned, mixed with a little fresh nitre.

This succeeded so well that considerable quantities of these residues were purchased from the other makers over the country, and used up in this way.

These sulphur ashes contained from 25 to 50 per cent. when only once burned, and cost about 5*l.* per ton.

At the end of this year, a brick furnace, heated artificially, was attached to one chamber, and in a short time two chambers were attached to one furnace, which was placed between them and had a flue to each chamber.

The furnace burned the sulphur ashes mixed with a portion of fresh sulphur and nitre. It worked almost continuously, the gas passing into one chamber for a certain time, the other meanwhile being shut off by means of a damper, then the first chamber damper was closed and the second opened. No. 1 chamber was allowed to condense for some time, and then the air valves and doors were opened to let in a fresh supply of air.

There were 14 chambers at work in this year, during which a produce of about 200 of acid of 1·84 sp. gr. seems to have been obtained from 100 sulphur with 15 per cent. nitre. At the end of 1809, there were in operation 26 chambers.

In 1811, furnaces heated externally were applied to all the chambers, which were increased in number to 32, arranged in sets of two or three each.[1]

Sulphur ashes were used in large quantity.

The strength of the chamber acid, which had hitherto only been about 50° to 60° Twaddell, was gradually raised, and steam having been introduced about 1813 or 1814, a strength of 100° to 120°

[1] Red-hot plates of about a foot square and ¾ inch thick in use generally by other makers.

Twaddell was attained, and the process became more or less a continuous one.

From this time till about 1840, the changes in the manufacture were chiefly in the direction of improving the form of the apparatus, both in chambers and furnaces.

Pyrites was first used in 1840.

Communications with Hill, show that he was using pyrites in 1820 in a chamber of 50 in. by 26 in. by 22 in.; and Gay Lussac's method of recovering the nitrous compounds by absorbing them in strong vitriol, in 1844 introduced by a Mr. De Courcy.

This was followed almost immediately by Mr. C. T. Dunlop's method of manufacturing bleaching powder by the decomposition of a mixture of salt and nitrate of soda, which gives off a mixture of chlorine and nitrous acid. The latter is absorbed in strong vitriol and used as the source of nitrous acid in the chambers.

Various methods of denitrating this nitrous vitriol were from time to time tried, and the most successful perhaps prior to the introduction of the Glover tower, was a wall of coke extending across the chamber, through which all the gases had to pass while it was kept supplied with nitrous vitriol at various points so as to expose it in as thin films as possible. This method worked extremely well for many years.

The methods now in use in the manufacture at these works differ but little from the general system in use by the other large manufacturers of Great Britain.

The following list of vitriol makers in England is interesting, compiled in 1820.

Name.	Situation of works.
Brandrum & Co.,	London.
Farmer,	"
Smith,	"
Hill,	"
D. Taylor & Sons,	"
Liddiard,	"
Dobbs,	"
Skey & Beudley,	Staffordshire.
Caves & Co.,	Bristol.
Bush,	"
Dobbs,	Birmingham.
Austen,	"

CHRONOLOGY—SULPHURIC ACID—GLASGOW, &c.

WORKS.	DATE.	No. of Chambers.	Length	Breadth.	Height	Method of Burning.	Produce from 100 Sulphur, @ 1·84 sp. gr.	Per Ct. Nitre.	Cost per Ton.	REMARKS.
			Feet.	Feet.	Feet.					
Mr. M—'s Business	1798	...	...	...	...	On Plates.	200 ?	28	£32	25 tons Sulphur, strength of acid unknown if 148°, yield would be 200 per cent.
Bealy's	1799	6	12	10	10	do.	130	14¼	£21 10*s.*	Cottage roofs—run off each 6 weeks.
Prestonpans	1800	108	14	4½	10	do.	198	13	£21	Cost delivered to customers—run off in 10 weeks.
Burntisland	1805	360	8	4	6	do.	173	16·6	...	Cost not known.
Nisbet	1805	...	...	...	...	... ...	187	25	£29	Small work.
A. W. & Co.	1805	6	...	...	...	... ...	187	19	£28 15*s.*	
W. N	1811	...	...	...	...	... ...	200	23	...	Sul. ashes re-burnt on red hot plates
Prestonpans	1812	108	14	4½	10	... ...	220	Not known	...	do. do. do.
do.	1813	108	14	4½	10	... ...	...	...	...	400 to 500 glass retorts at work 2 charges pr. wk. Chambers in 9 sets of 12 each, 1 set run off each wk.
Kenny, Dublin	1813	2	45 25	17 17	10 12	... ...	...	...	...	
J. L——d	1813	...	...	...	...	... ...	200	20·8	...	
Camlachie	1820	...	...	...	...	... ...	263*	13	...	*Acid strength, supposed, 144° Tw.
Port-Dundas	1824	1	70	18	...	... ...	246*	...	...	* do. do. do.
St. Rollox	1803	6	12?	10?	10?	... ...	...	14	...	
do.	1806	...	...	...	...	... ...	185	12	£20 13*s.*	
do.	1807	...	...	...	...	... ...	193	15½	£18 15*s.*	
do.	1809	26	No Record			... ...	...	...	...	
do.	1811	32	60?	14?	12?	Furnace.	...	...	...	

Name.	Situation of works.
Phipson, ...	Birmingham.
Paton, ...	"
Bower & Sons, ...	Leeds.
Norris & Son, ...	Halifax.
Betson, ...	Rotherham.
Doubleday, Easterby & Co., . .	Newcastle.
Rawson & Sons, ...	Bolton.
Do., ...	"
Watkins, ...	Manchester.
Mutrie & Co., ...	"
Do., ...	Whitehaven.

23 works in all at this date.

Part III.—Bleaching Powder.

It was in the year 1785 that Berthollet discovered the bleaching action of chlorine; he showed the experiments to Watt in 1786, and he on his return to Glasgow actually bleached a considerable quantity of linen by means of a solution of chlorine in water.

In the following year a work was established in Aberdeen by Professor Copeland and the then Duke of Gordon, for the production of solution of chlorine, which they supplied to the neighboring bleachers.

The injurious effects of the chlorine both on the workmen and on the goods caused the introduction of a portion of potash to the water, which had the effect of retaining the chlorine.

This method was extensively adopted by bleachers all over the country; the solution, however, did not keep well.

In 1798, Mr. Charles Tennant (then engaged in bleaching operations at Darnley) patented the use of lime instead of potash, and in conjunction with Mr. M'Intosh and others, began the manufacture of "lime bleaching liquor." They also granted licenses to bleachers, giving the right to manufacture it for themselves. The method was most successful, but the patent was disputed and declared untenable.

Mr. Tennant, however, in the following year patented a method of producing a dry compound of lime and chlorine, which, long known as Tennant's bleaching salt, and more recently as bleaching powder, has completely revolutionized the process of bleaching.

Works were erected for the manufacture of this article at St. Rollox in the same year.

It was prepared originally by the decomposition of a mixture of salt, manganese and sulphuric acid, in a leaden still heated by a

water bath, and the chlorine was absorbed by lime (slaked and sifted) in a leaden receiver, the lime being agitated from time to time by means of a stirrer.

The proportions used in the beginning of the year 1800 were:—

Vitriol,	4
Manganese,	2
Water,	4
Salt,	4½

These proportions were altered from time to time, and muriates of potash, lime and magnesia were tried, with a view of obtaining by-products of greater value.

The question of the utilization of the by-products was one which became very serious indeed as the production increased, and in 1803 the question was solved for the time by the production of an impure soda or black ash from the still residuums.

As the demand became greater, various methods were adopted to increase the production, and finally the system of stone stills, heated externally by means of steam, was adopted.

In 1823 the use of muriatic acid prepared from salt was employed. At first the process was tried with manganese in a separate vessel, through which passed the muriatic acid driven off from the salt. Very soon this was abandoned for the method now in use of condensing the acid in water, and using it in the liquid state.

The salt was at first decomposed in iron cylinders, and the condensers were cylindrical and of earthenware.

The condensing arrangement of Mr. Gossage was adopted soon after its introduction to the trade, and has been most successful at these works, which, indeed, are laid down with the object of utilizing the muriatic acid to the utmost—the loss of muriatic acid being now (1876) under 1 per cent.

Within the last few years there have been erected in the district three works for the production of this article in connection with the alkali manufacture, viz., those of Messrs. Orr and Brown and Henderson, both at Irvine, and Messrs. Arnott Bros., Kirkintilloch.

The method of manufacture devised by Mr. C. T. Dunlop is still a specialty at the St. Rollox Works.

It consists in decomposing a mixture of nitrate of soda and salt with sulphuric acid. This yields a mixture of nitrous acid and chlorine gases, with traces of muriatic acid.

The nitrous acid is separated by absorption in strong sulphuric acid, the muriatic acid by water, while the chlorine passes on to the bleaching powder chambers to be absorbed by the lime.

An idea of the progress of the bleaching powder manufacture may be had from the following table :—

Table of Prices Realized.

Year.	Tons.	Price.
1799–1800 . .	52 . .	£140 0 0
1801 . . .	96 . .	130 0 0
1802 . . .	72 . .	112 0 0
1803 . . .	Not known.	
1804 . . .	131 . .	112 0 0
1805 . . .	147 . .	112 0 0
1810 . . .	239 . .	93 0 0
1815 . . .	377 . .	81 0 0
1820 . . .	333 . .	60 0 0
1825 . . .	910 . .	27 0 0
1830 . . .	1447 . .	25 0 0
1835 . . .	2122 . .	22 0 0
1840 . . .	2383 . .	26 0 0
1845 . . .	3861 . .	16 0 0
1850 . . .	5719 . .	14 0 0
1855 . . .	6260 . .	11 0 0
1860 . . .	7459 . .	11 0 0
1865 . . .	8431 . .	10 10 0
1870 . . .	9251 . .	8 10 0

(To be continued.)

Disinfectants.—(*Dingl. polyt. J.*, ccxix, 375.)—*Potassium permanganate* solution does not cause the death of infusoria for a long time. The spores of *Mucor* and *Penicillium* grow in strong solutions of this salt. Bacteria are killed by concentrated solution, but they increase in solution of 1·1000. When meat is placed in a solution of this salt, it is permeated with the liquid, but the action results in a decomposition of the permanganate, after which the meat is acted on by bacteria, etc. Permanganate may be advantageously employed for washing wounds; for disinfection of decaying matter it is, however, useless.

Dry *chlorine* is without action on the lower organisms; attempts to disinfect clothes, etc., by fumigation with chlorine are therefore useless.

Phenol quickly kills all lower organisms; it is, therefore, one of the best of all disinfectants.

Heat kills many of the lower organisms. Hot steam and water may become good disinfectants. M. M. P. M.

ON THE DEVELOPMENT OF THE CHEMICAL ARTS DURING THE LAST TEN YEARS.[1]

By Dr. A. W. Hofmann.

From the *Chemical News*.

Continued from Vol. cii, page 432.

As it appears that the workmen do not make use of the respirators with which they are furnished, and at most merely tie a cloth over the mouth and nose when decanting large quantities of bromine, the most important point is to secure an efficient ventilation in all parts of the works. By attention in this respect, combined with the above-mentioned dietetic regulations, it has been found practicable to maintain the health of the workmen at Stassfurt, during the eight years of the existence of the bromine manufacture, so long as they refrain from the use of spirituous liquors (Frank).

(The editor of this Report has had opportunity during a recent excursion to Stassfurt to visit Frank's bromine works, and, it may be permitted him, to add certain results from his own observation in order to complete what has above been given in bold outline.)

The distillation of bromiferous mother-liquors with manganese and sulphuric acid is conducted in large cubic stone vessels made in one piece, and belted with iron bands in case of a fracture. Their average capacity is 3 cubic metres. At some distance from the bottom is a perforated plate of the same kind of stone, upon which the manganese is placed in fragments of the size of a nut. The stone trough is covered with a heavy plate of the same material, which is raised and lowered by means of a rope with a counterpoise playing over a pulley. In this cover there is introduced a thick stoneware pipe for the introduction of steam; and it is also provided with a man-hole, an aperture for pouring in the bromiferous liquid and the dilute sulphuric acid, and an opening for the escape of the bromine vapors.

Few stones are suitable for the construction of these vessels, and when the bromine manufacture was introduced at Stassfurt there was great difficulty in finding a suitable quality. Almost all the

[1] "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

stones tried experimentally after a time allowed the chloride of manganese to ooze through, and required to be coated with tar to overcome this defect. This, however, gave rise to a new inconvenience, considerable quantities of bromine being lost by the conversion of the hydrocarbons of the tar into bromine compounds, and the bromine itself becoming contaminated. Dr. Frank estimates the loss for every new coating of tar at about 50 kilos. of bromine. Latterly a kind of stone has been found in the neighborhood of Porta Westphalica which does not require this costly preparation and can be used at once. Still the high price of these stone troughs has given rise to attempts to manufacture bromine stills with large plates of slate, cramped together with iron bands and screws. A final decision has not yet been obtained.

The bromine lyes are kept in a large reservoir situate above the stills, in which they can be preliminarily heated by means of a coil of steam pipe. The height of the liquid is indicated by a float to which is attached a cord passing over a pulley and supporting at its other extremity a weight suspended in front of a scale, so that the workman in charging the stills is guided by the movements of this weight.

The stone lid is closed by its own weight, but may be further loaded with extra weights; the joints are made good with plastic clay. As we have already mentioned, the cover is raised by means of a counterpoise, but only when the apparatus is filled anew with manganese. The charge is about 4 cwts., which quantity serves for an entire series of operations. Not all qualities of manganese are fit for this purpose, that of medium hardness being the most suitable. The charges of bromine liquor and of sulphuric acid are introduced through one of the small apertures in the stone cover, which is immediately afterwards closed with balls of clay held down by iron weights. As soon as the apparatus is thus suitably secured steam is turned on and bromine vapors immediately escape in abundance through the leaden tube cemented into the second aperture in the cover. This leads to a worm surrounded with cold water in which the bromine is condensed. The original leaden worms have long ago been replaced by a stoneware apparatus.

At first the excellent but very costly stoneware worms of the English establishment "Lambeth Potteries," were used, but latterly German apparatuses have been employed, especially those furnished by

the firm of Jannasch, in Bernburg. The lower end of the stoneware worm opens by means of a bent glass adapter into the central tubulure of a large three-necked Woolff's bottle holding about 8 litres, in which bromine and bromine-water collect. Into one of the lateral necks is fixed a movable glass syphon, by means of which the bromine-water can be drawn off into stoneware jugs. From the other neck a bent glass pipe passes down to the bottom of an iron vessel, which widens upwards in a conical shape and which is filled with water and iron turnings. Vapors of bromine which have not been condensed in the bottle are arrested by the iron. The impure chloriferous bromide of iron, as well as the bromine-water syphoned off are returned to the stills for the next operation.

At the beginning of the process scarcely anything but bromine is evolved, afterwards chloride of bromine escapes, and ultimately, when there is no more bromine in the apparatus, pure chlorine is evolved. Dr. Frank, for the instruction of the author, kindly caused an operation to be carried to the very end so that the three stages of the process, which are easily distinguished by the color of the gas in the glass adapter, were fully exhibited. In the ordinary routine of the works the operation is stopped when the chloride of bromine begins to be given off. The workmen in these establishments receive in addition to their wages a premium on the quantity of bromine obtained. Hence it is their interest to get through the greatest possible number of operations, and as the bromine lye is on hand in abundance they break off the operation as soon as the distillation of the bromine slackens. The quantity of sulphuric acid also is so calculated that it only just suffices for the liberation of the bromine in a charge. Hence the bromine obtained ought to be free from chlorine. It is found, however, in practice that, on account, doubtless, of the imperfect mixture of the reagents, chloride of bromine is evolved even in the earlier stages of the distillation. The quantity of acid (hydrochloric acid?) must also be noticed, which is given off towards the end of the process and produces such an evolution of hydrogen in the iron vessel that its contents froth strongly. In order to prevent loss by running over, a broad saucer-shaped rim is cast on the iron at the distance of some centimetres from its upper margin in which the overflow collects and is conducted away by a side tube into a stoneware jug.

Each operation takes up about two hours and yields from 2 to 2·5 kilos. of bromine. The two bromine works at Stassfurt are so

arranged that they are capable of producing 500 kilos. in twenty-four hours, but this quantity has never been actually furnished.

The arrangements for the ventilation of the bromine works are peculiarly interesting. The critical moment is when the manganese liquid is run out of the stone tanks, since it throws off vapors of chlorine and bromine in abundance. Yet the operation is performed without the lest inconvenience to the workman. Along the series of stills there runs a channel of brickwork, through which a powerful current of air is drawn by the great chimney of the works in a direction opposite to that in which the liquid runs off. The channel is situated so that the vent holes of the stills open into it. In front of every still there is introduced in the roof of the channel, a damper which is opened when the plug of the vent hole is about to be knocked out. The draught is so powerful that the workmen are not in the slightest degree incommoded by the vapors evolved from the stream of solution of manganese. The workshops smell distinctly of bromine, but the odor is far fainter than that which is experienced in our scientific laboratories during the bromation of organic substances.

As has been already remarked, crude bromine always contains a little chlorine, even when, according to the Stassfurt practice, the Woolf bottle is allowed to become slightly warm towards the end of the operation, so as to drive the volatile chloride of bromine over into the iron-turnings. A rectification is therefore requisite. This takes place in glass retorts containing about 15 litres, the necks being cemented into receivers bedded in cold water. Each retort is set in a separate sand-bath, so that if one happens to burst—and such misfortunes cannot be avoided—the injury may be limited as much as possible. Only a slight aqueous fraction contains chlorine; it is withdrawn and returned to the stone stills. The rectification lasts about twenty-four hours. The atmosphere in the rectifying-house is more offensive than that in the still-houses, since all currents of air must be carefully avoided. The workmen, however, require to enter this room from time to time. Moreover there are especial arrangements which render it possible to decant the bromine both out of the Woolf's bottles into the retorts, and from the receivers into the vessels used for transport without any annoyance from the vapors abundantly evolved during these operations. The decantation is performed in wooden chests, through which a violent current of air is drawn by the great chimney. The workmen soon acquire such dexterity and

accuracy in these manipulations that they are content to cover the respiratory organs with a wet cloth, and disdain to make use of the ventilating arrangements placed at their disposal.

(At Stassfurt, bromine is sent off in strong glass bottles holding 2·5 kilos. The well-ground stoppers are sealed with shellac, luted with clay, and tied up with parchment paper. Four or twelve such bottles are packed in a chest.—A. W. H.)

Iodine.—The rapid extension in the demand of the splendid violet, blue, and green coal-tar colors, which are prepared by means of the iodides of the hydrocarbons, has in the last few years occasioned a notable increase in the consumption of iodine. The production, from very simple reasons, could not keep pace with the growing consumption, which of course led to a considerable increase in the commercial value of a body relatively of such rare occurrence in nature. Its price has been further increased by the circumstance that the seaweed ashes of England and France (Kelp, Varec) have become less remunerative to the producers. Formerly these weed ashes served to supply a considerable part of the demand for the salts of potash, but since the utilization of the well-known "Abraum salts" of Stassfurt the extraction of potash salts from seaweed ashes has become so unremunerative that the loss in the returns of the kelp trade has to be balanced by a rise in the price of the iodine.[1]

The hope of a fall in the commercial value of iodine in consequence of its extraction from the mother-liquors of nitrate of soda has not been fulfilled. The production of iodine from this source has increased but little, and some nitre refineries, which had commenced the utilization of the iodiferous mother-liquors, have again abandoned the attempt.[2] On the other hand, in tinctorial industry attempts have been made to dispense with the use of iodine. Although the attempt to employ bromine in place of iodine (see "Bromine") has failed,

[1] According to a letter from Mr. E. C. C. Stanford, of Glasgow, to Prof. A. W. Hofmann, a ton of chloride of potassium in 1863 cost £21 13s.; in the ten following years on an average £15 15s.; and is now worth only £7 10s. The price of iodine has risen in a corresponding degree; in 1863 an ounce of iodine cost 4½d.; on the average of the following ten years 7d.; whilst it is now worth 1s 3d. per ounce.

[2] According to private communications from M. E. Schering the production of iodine from the mother-liquors of soda saltpetre is again on the increase. A Peruvian nitre refinery, which separates the iodine as cuprous iodide by means of bisulphite of soda and sulphate of copper, produced, in 1873, 15,000 kilos. cuprous iodide, and is about to increase its production to 50,000 kilos., corresponding to 30,000 kilos. of iodine.

other methods have recently been discovered for producing the most magnificent violet, blue, and green tar colors without the aid of iodine. Nevertheless the price has not been essentially reduced since the methods for preparing the dyes without iodine have not by any means been adopted in all establishments.

In addition to the tinctorial arts iodine is employed in scientific chemistry, where its importance is incalculable, and also in photography and in medicine.

As regards recently discovered sources of iodine we have already mentioned the mother-liquor of Chilian nitre. No others of importance have been discovered. Leuchs[i] indeed points out that the flue dust of blast-furnaces contains compounds of iodine along with other soluble salts. Thus from the dust of the Rosenberg furnace, near Sulzberg, he obtained 0·034 per 1000; from the Komoran furnace, near Herzowitz, 0·042; and from that at Kreutzthale 0·146, and calculated that 35½ lbs. iodine could be annually prepared at the first-mentioned furnace. But even in the improbable event that the iodine thus occurring could be extracted at a remunerative cost the total production would still be quite insignificant.

As for the total production of iodine there exist few numerical statements from which it can be ascertained. By far the greatest quantity is obtained in England and France. In the year 1871 the quantity produced in Great Britain reached 114,799 lbs., 9-10ths of which came from Glasgow. One of the works there (W. Paterson) in the year 1867 alone produced 112,000 lbs.[ii] In France the production in 1867 was 55,600 kilos.; therefore rather less than in England.

In 1868, 40 kilos. were daily prepared at Tarapaca from Chilian nitre (Balard) corresponding to a yearly production of 290 to 300 cwts. This quantity, however, must be considerably reduced if we remember that Sticht[iii] found only 50 per cent. of real iodine in a Chilian sample.

The method of extracting iodine is essentially unchanged notwithstanding many proposed improvements.

In the Report of the London Exhibition of 1862, A. W. Hofmann describes the process of Stanford which was then taken up with great

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[i] Leuchs, *Deutsche Industrie Zeit.*, 1868, 408. *Wagner Jahresber.*, 1868, 15.

[ii] *Deutsche Indust. Zeit.*, 1867, 8.

[iii] Sticht, *Wagner Jahresber.*, 1869, 221.

zeal, and for which a medal was awarded by the jury. Its principle is the preliminary distillation of the seaweed, and the utilization both of the volatile products and of the residual charcoal with its mineral constituents. According to this process 20,000 cwts. of seaweed yielded 12,860 litres of empyreumatic oil, 31,000 cubic metres of illuminating gas, and 26 cwts. of iodine, besides other less important products.[i] In spite, however, of the favorable expectations which were entertained by experts, this process has evidently failed in practice.[ii] The rock on which the invention has been wrecked is the troublesome and costly carriage of the seaweeds, since a great weight of water must be conveyed along with a comparatively small quantity of solid matter. Moride[iii] has indeed proposed to improve this method. He proposed to dry the weeds in portable furnaces where they are obtained, but nothing further has been heard of the distillation of seaweed and the production of iodine from the residual charcoal.

The method of extracting iodine from the mother-liquors of kelp is still the same well-known process, over which it is needless to waste a word. New methods have been proposed, but have led to no alterations in practice. We may mention the method invented by Lauroy.[iv] He saturates the mother-liquors of Varec with hydrochloric acid, removes the precipitate thus produced, and passes nitrous and hyponitrous acid into the clear liquid. Iodine is thus precipitated, whilst the bromides, simultaneously present, are not decomposed.

The process of extracting iodine from the mother-liquors of Chili nitre, which was at first introduced by Thiercelin in the works of the Société Nitrière, at Tarapaca, and by which, as has been already stated, 40 kilos. of iodine were obtained there daily, is in brief as follows:—The iodic acid present in the mother-liquors is reduced by an exactly sufficient amount of sulphurous acid. The iodine thus precipitated is placed upon a sand filter in a large stoneware vessel with a perforated bottom, which allows the greater part of the saline liquid saturating the iodine to drain away. It is then transferred by means of stoneware spoons into a trough of gypsum with thick sides, which quickly absorbs the rest of the liquid. The crude iodine thus obtained is either offered for sale in this state or submitted to subli-

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[i] *Wagner Jahresber.*, 1864, 186 (from *Journ. de Chim. Medic.*).

[ii] See note at the end of this article.

[iii] Moride, *Comptes Rendus*, lxii, 1002. *Moniteur Scient.*, 1866, 445.

[iv] Lauroy, *Monit. Scient.*, 1868, 1042.

mation. Thiercelin subsequently employed for the precipitation of the iodine nitrous acid, which he obtained by the ignition of a mixture of 5 parts soda-saltpetre, and 1 part charcoal (Duhamel's process for the manufacture of soda).

G. Langbein reports that he has introduced another process in the works of the firm Gildemeister & Co., as the process of Thiercelin disregards the iodine existing as sodium iodide along with the iodic acid. This does not, however, apply to the more recent method of Thiercelin, since hydriodic acid is very readily decomposed by nitrous acid.

The compounds of iodine find little application in manufactures, and are therefore merely produced on a small scale. Proposals for improved methods of preparation are therefore of limited interest and require but a very brief notice.

For the preparation of the iodides of potassium, calcium, and lithium, Liebig[i] proposes to form a solution of phosphoric and hydriodic acids by the reaction of amorphous phosphorus, iodine, and water, and to saturate the acid liquid with caustic baryta. Phosphate of baryta is precipitated and iodide of barium remains in solution, from which (Pettenkofer) any desired iodide may be obtained by precipitation by means of a sulphate. In preparing calcic iodide the acid may be neutralized with milk of lime.

Rud. Wagner[ii] proposes to form the iodides by decomposing sulphides with iodine. For this purpose the sulphite of barium is particularly adapted, which is diffused in water and treated with iodine, yielding sulphate of baryta, marketable as *blanc fixe* and iodide of barium. But the process already in use of reducing sulphate of barium and decomposing the sulphide thus obtained with iodine is evidently simpler.

Fluorine.—Fluorine, which it was hoped would, in its compounds, prove capable of important industrial applications, has in no manner fulfilled the expectations entertained. Many attempts made with this view down to the year 1867 have proved fruitless. Amongst such we may remember the proposal of Weldon[iii] to prepare soda by means of hydrofluoric acid. A solution of sulphate of soda was decomposed by means of hyrofluoric acid, obtained either by heating a

[i] Liebig, *Ann. Chem. Phar.*, cxxi, 222. *Wagner Jahresber.*, 1862, 257.

[ii] Wagner, Bayer, Kunst, &c., *Gewerbbl.*, 1862, 235. *Wagner Jahresber.*, 1862, 261.

[iii] Weldon, *Dingl. Pol. Journ.*, clxxii, 228.